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**Popoveniuc et al.**

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(54) **SYSTEM AND METHOD FOR  
RECOGNIZING MALICIOUS CREDENTIAL  
GUESSING ATTACKS**

(58) **Field of Classification Search**  
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U.S.C. 154(b) by 0 days.

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Jul. 12, 2013, now Pat. No. 9,276,919, which is a  
(Continued)

(57) **ABSTRACT**

A first identity claim and a first attempt to prove password  
possession are received. As a result of determining that the  
first attempt to prove password possession is a match to a  
password in a set of passwords, but that the first identity  
claim is a mismatch to an identity that corresponds to the  
password, an authentication process that includes increment-  
ing a counter associated with the password is performed. A  
second identity claim and a second attempt to prove pass-  
word possession is received. As a result of determining that  
the second attempt to prove password possession is a match  
to the password, an authentication process that includes  
incrementing the counter associated with the password only  
if the second identity claim is a mismatch to the first identity  
claim is performed.

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(52) **U.S. Cl.**

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(2013.01); **H04L 63/08** (2013.01);  
(Continued)

**20 Claims, 7 Drawing Sheets**

200

	202	204	206	208	210	212	
	Account	Attempted Credential	Timestamp	Successful	Distinct Counter	Lifetime Counter	...
214a	Account1	password	8:03	N	1	1	...
214b	Account1	PASSWORD	8:04	N	2	2	...
214c	Account1	PASSWORD1	8:05	Y	0	2	...
214d	Account1	password	11:10	N	1	2	...
214e	Account1	password1	11:11	N	2	2	...
214f	Account1	password2	11:12	N	3	4	...
214g	Account1	Password	11:13	N	4	5	...
214h	Account1	Password1	11:15	N	5	6	...
214i	Account2	houston	11:45	N	1	1	...
	.	.	.	.	.	.	...
	.	.	.	.	.	.	...
	.	.	.	.	.	.	...

**Related U.S. Application Data**

continuation of application No. 13/248,736, filed on Sep. 29, 2011, now Pat. No. 8,490,162.

(52) **U.S. Cl.**

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(58) **Field of Classification Search**

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See application file for complete search history.

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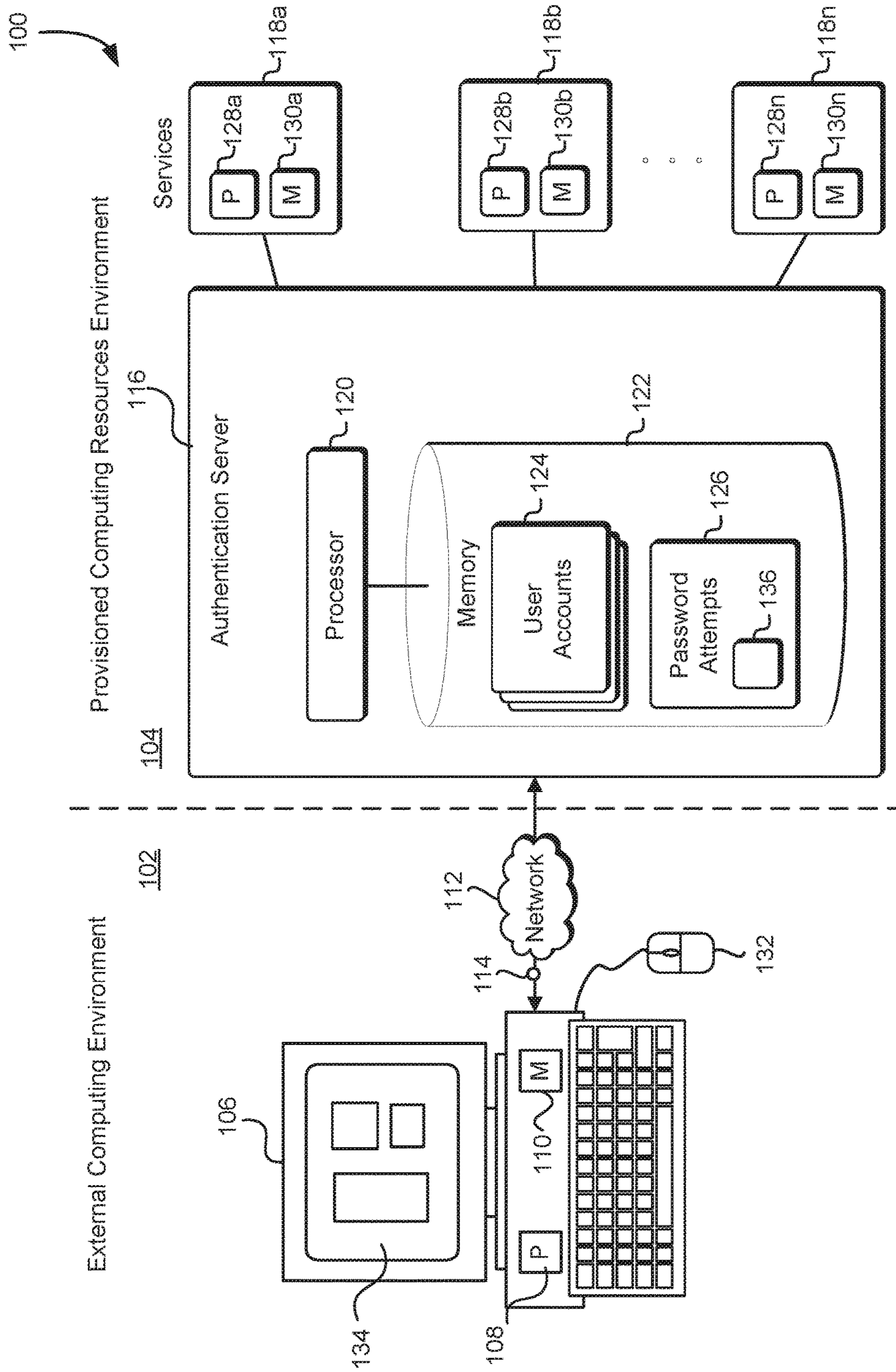


FIG. 1

200

	202	204	206	208	210	212	...
	Account	Attempted Credential	Timestamp	Successful	Distinct Counter	Lifetime Counter	...
214a	Account1	password	8:03	N	1	1	...
214b	Account1	PASSWORD	8:04	N	2	2	...
214c	Account1	PASSWORD1	8:05	Y	0	2	...
214d	Account1	password	11:10	N	1	2	...
214e	Account1	password1	11:11	N	2	2	...
214f	Account1	password2	11:12	N	3	4	...
214g	Account1	Password	11:13	N	4	5	...
214h	Account1	Password1	11:15	N	5	6	...
214i	Account2	houston	11:45	N	1	1	...
	°	°	°	°	°	°	°
	°	°	°	°	°	°	°
	°	°	°	°	°	°	°

FIG. 2

300

	302	304	306	308	310	300
	Attempted Credential	Attempted Account	Timestamp	Successful	Distinct Counter	o o o
312a	Houston	Account1	8:03	N	1	o o o
312b	Houston	Account2	8:04	N	2	o o o
312c	Houston	Account3	8:05	N	3	o o o
312d	Houston	Account4	11:10	N	4	o o o
312e	Houston	Account5	11:11	N	5	o o o
312f	Houston	Account6	11:12	N	6	o o o
312g	Houston	Account6	11:13	N	6	o o o
312h	Houston	Account7	11:15	N	7	o o o
312i	Houston	Account8	11:45	N	8	o o o
	o	o	o	o	o	o o o
	o	o	o	o	o	o o o
	o	o	o	o	o	o o o

FIG. 3

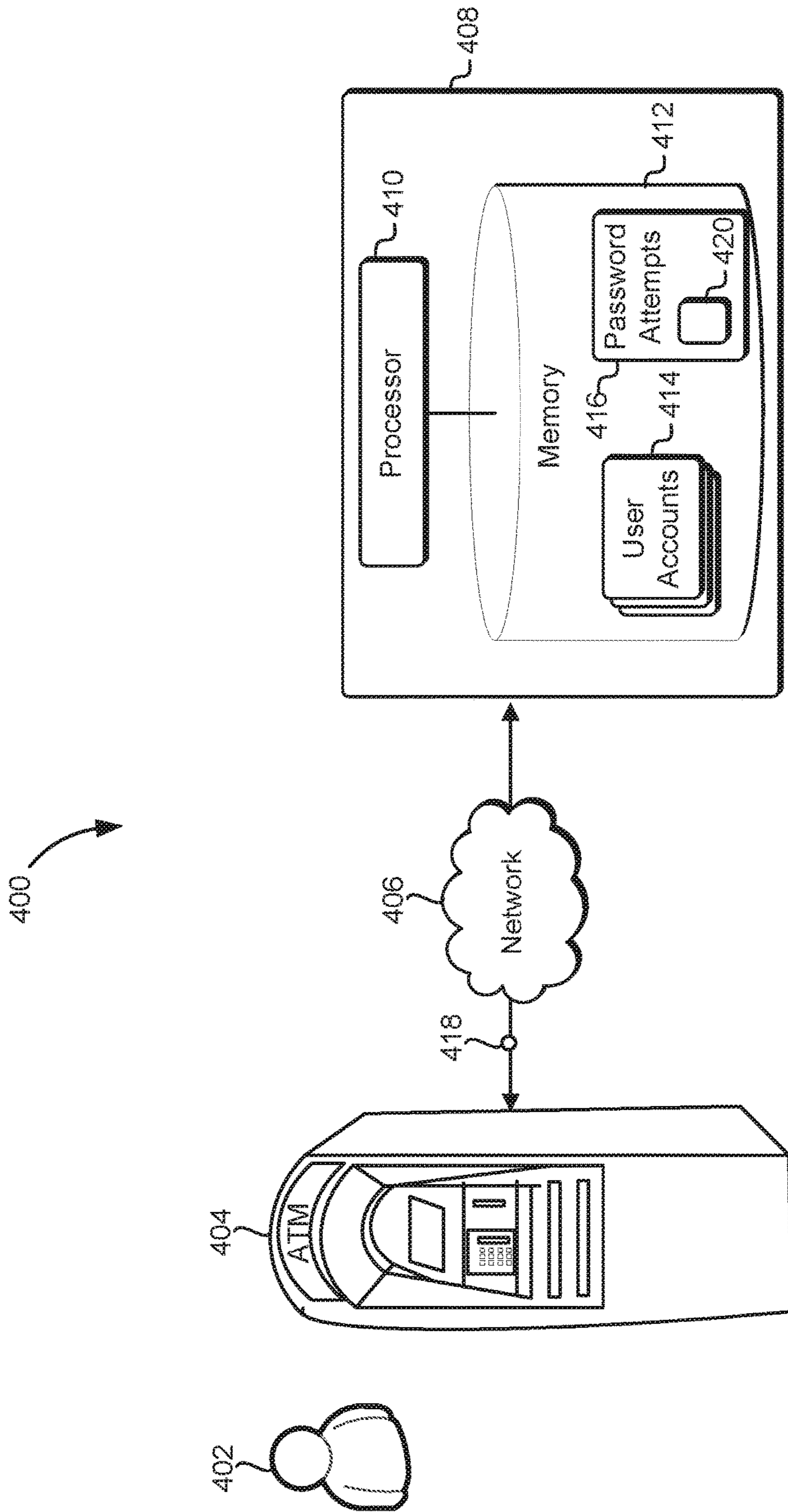


FIG. 4

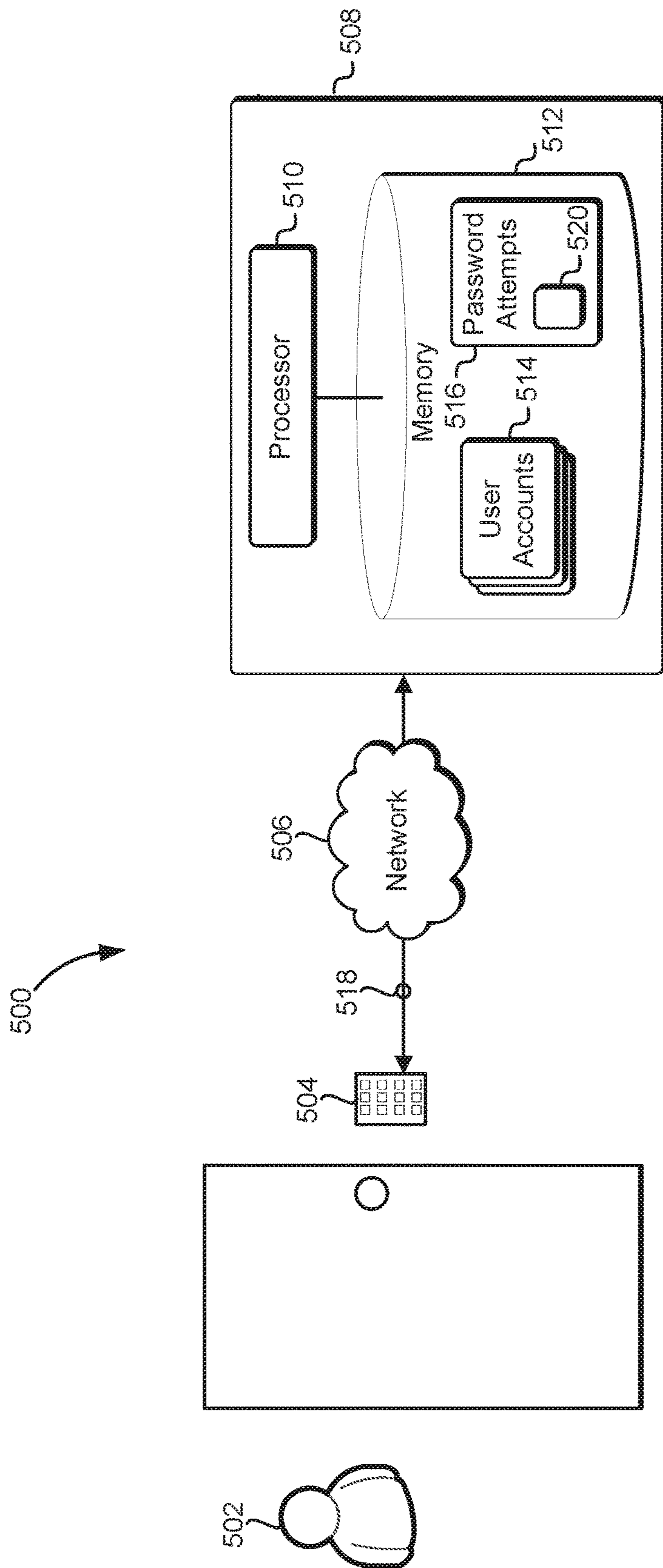
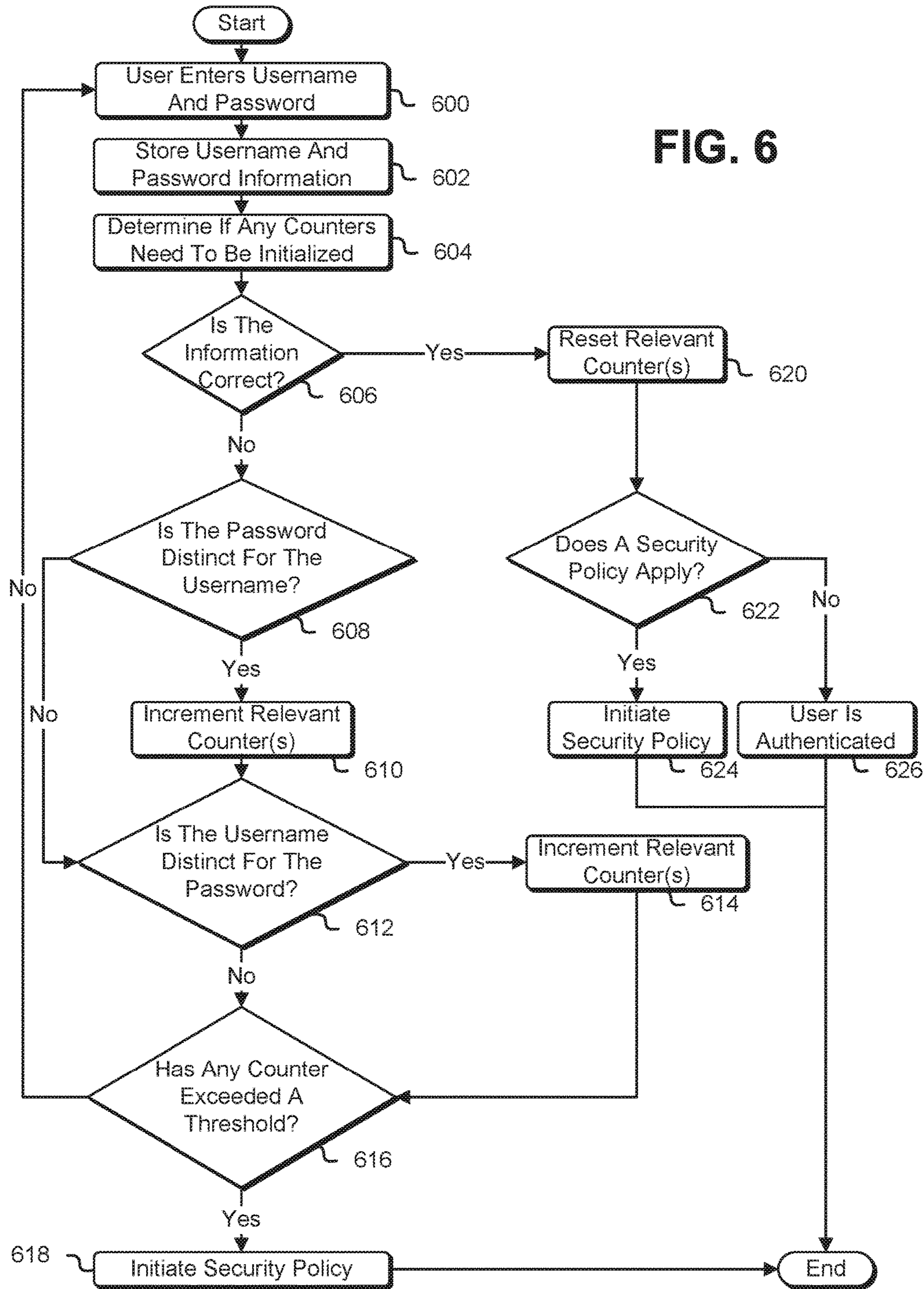


FIG. 5





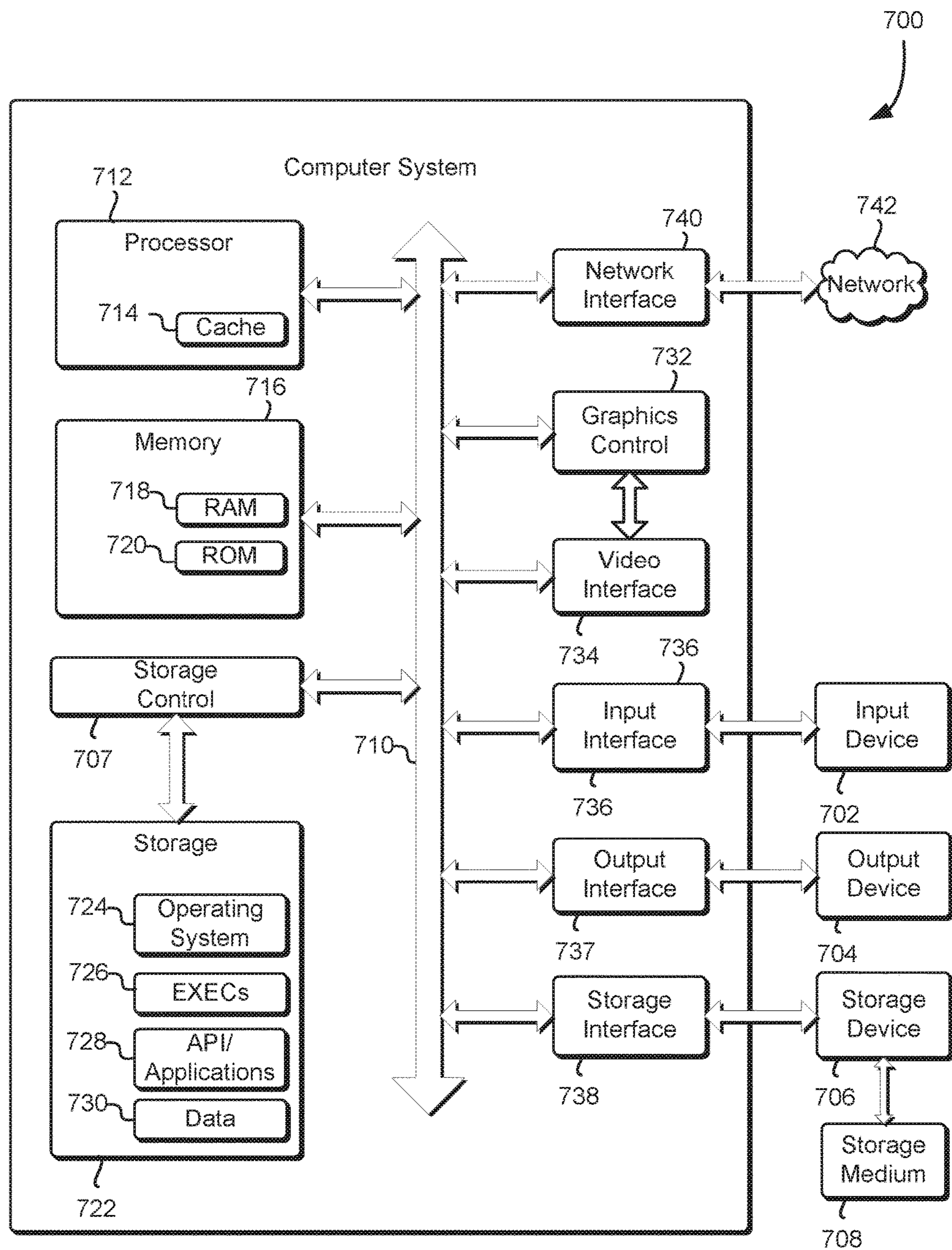


FIG. 7

## SYSTEM AND METHOD FOR RECOGNIZING MALICIOUS CREDENTIAL GUESSING ATTACKS

### RELATED APPLICATION

This application is a continuation of U.S. patent application Ser. No. 13/940,625, filed on Jul. 12, 2013, entitled "SYSTEM AND METHOD FOR RECOGNIZING MALICIOUS CREDENTIAL GUESSING ATTACKS," which is a continuation of U.S. patent application Ser. No. 13/248,736, filed on Sep. 29, 2011, entitled "SYSTEM AND METHOD FOR RECOGNIZING MALICIOUS CREDENTIAL GUESSING ATTACKS," the content of which are incorporated by reference in their entirety.

### BACKGROUND

An enterprise may offer a variety of services to a user. Some of these services may require the authentication of user credentials before access is granted to the services. To prevent a malicious entity from guessing the correct user credentials, an enterprise may limit the number of incorrect attempts at authentication to a specific number. However, this may lead to freezing out a user, from a user account, that made honest mistakes when entering credentials.

### BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the present disclosure and its advantages, reference is made to the following descriptions, taken in conjunction with the accompanying drawings in which:

FIG. 1 illustrates an example system for differentiating between malicious password guessing and honest mistakes;

FIG. 2 illustrates example attempted user credentials data, which may be used by the example systems of FIG. 1, 4, or 5 for differentiating between malicious password guessing and honest mistakes, according to certain embodiments of the present disclosure;

FIG. 3 illustrates example attempted user credentials data, which may be used by the example systems of FIG. 1, 4, or 5 for differentiating between malicious password guessing and honest mistakes, according to certain embodiments of the present disclosure;

FIG. 4 illustrates an example system for differentiating between malicious password guessing and honest mistakes;

FIG. 5 illustrates an example system for differentiating between malicious password guessing and honest mistakes;

FIG. 6 illustrates an example method for differentiating between malicious password guessing and honest mistakes which may be performed by the example system 100 of FIG. 1, the example system 400 of FIG. 4, or the example system 500 of FIG. 5 according to certain embodiments of the present disclosure; and

FIG. 7 illustrates an example computer system 700 that may be used for one or more portions of the example system 100 of FIG. 1, according to certain embodiments of the present disclosure.

### DETAILED DESCRIPTION

Enterprises often provide their users with access to a variety of services that meet the needs and demands of each user. For example, an enterprise may desire to process transactions, store data, or host a website. Before granting a user access to these services, an enterprise may wish to

authenticate a user's user credentials. For a variety of reasons that may go against the interests of the enterprise, a malicious user may wish to also access these particular services. Therefore, an enterprise may wish to make its service environment more secure by implementing various security measures. One security measure may be to limit the number of failed log-on attempts allowed for a particular user account. One purpose of this limit is to prevent a malicious entity from randomly guessing user credentials for a particular account by using an automated computer program or other means. This results in a large number of authentication attempts using distinct user credentials. However, the enterprise may have no way to differentiate between a malicious user entering numerous distinct user credentials and a bona fide user that is mistakenly entering the wrong user credentials, some of which may be identical. Because both sets of users are treated the same, the enterprise may face the problem of bona fide users locking themselves out through actions that pose no actual security risk. By differentiating between malicious activity and some form of inadvertent activity that poses no actual threat it becomes possible to set more sensitive thresholds to lock out malicious password guessing more quickly.

Certain embodiments of the present disclosure provide techniques for differentiating between malicious password guessing and honest user mistakes. FIG. 1 through 7 below illustrate systems and methods for differentiating between malicious password guessing and honest user mistakes.

FIG. 1 illustrates an example system for differentiating between malicious password guessing and honest mistakes. In the illustrated example, credentials verification system 100 includes external computing environment 102 and provisioned computing resources environment 104. Although credentials verification system 100 is illustrated and primarily described as including particular components, the present disclosure contemplates credentials verification system 100 including any suitable components, according to particular needs.

Generally, credentials verification system 100 may be comprised of external computing environment 102 and provisioned computing resources environment 104. A user in external computing environment 102 may attempt to access service 118 in provisioned computing resources environment 104. To access service 118, provisioned computing resources environment 104 may need to authenticate the user. Therefore, a user may have to enter user credentials in external computing environment 102 before being granted access to service 118.

External computing environment 102 may include computer 106 and network 112. In general, computer 106 may be any computing device capable of receiving user input. For example, computer 106 may be a personal computer, laptop, workstation, telephone, electronic notebook, electronic book reader, tablet computer, Personal Digital Assistant (PDA), pager, or any other suitable device (wireless, wireline, or otherwise), component, or element capable of receiving, processing, storing, and/or communicating data to other components of credentials verification system 100. More specifically, computer 106 may comprise processor 108, memory 110, input device 132, and graphical user interface (GUI) 134. Processor 108 may include one or more microprocessors, controllers, or any other suitable computing devices or resources. Processor 108 may work, either alone or with components of credentials verification system 100, to provide a portion or all of the functionality of credentials verification system 100 described herein. Processor 108 communicatively couples to memory 110. Memory 110 may

take the form of volatile or non-volatile memory including, without limitation, magnetic media, optical media, RAM, ROM, removable media, or any other suitable memory component.

In certain embodiments, memory **110** may be internal or external to processor **108** and may include one or more instruction caches or one or more data caches. Instructions in the instruction caches may be copies of instructions in memory **110**, and the instruction caches may speed up retrieval of those instructions by processor **108**. Data in the data caches may include any suitable combination of copies of data in memory **110** for instructions executing at processor **108** to operate on; the results of previous instructions executed at processor **108** for access by subsequent instructions executing at processor **108**, or for writing to memory **110**; and other suitable data. The data caches may speed up read or write operations by processor **108**.

In certain embodiments, computer **106** may include input device **132**. Input device **132** allows the user to interact with computer **106** to input, store, delete, modify, or access data, or perform any other processing tasks. For example, input device **132** may be one or more of the following: a mouse, keyboard, touchpad, multi-touch interface, touchscreen, stylus, keypad, microphone, camera, or any input device that allows the user to interact with computer **106**.

In some embodiments, computer **106** may comprise GUI **134**. GUI **134** is generally operable to tailor and filter data presented to a user. GUI **134** may provide a user with an efficient and user-friendly presentation of information regarding the various components of credentials verification system **100**. GUI **134** may comprise a plurality of displays having interactive fields, pull-down lists, and buttons operated by the user. GUI **134** may include multiple levels of abstraction including groups and boundaries. In certain embodiments, GUI **134** may also operate as input device **132** allowing the user to use a touch interface to interact with computer **106**.

A user may use various components of computer **106** to enter user credentials to be authenticated before being granted access to services **118**. For example, GUI **134** of computer **106** may display a prompt to the user to enter user credentials. User credentials may be any data that can authenticate a particular user to provisioned computing resources environment **104**. For example, user credentials may be one or more of the user's name, a username, a password, an account name, a personal identification number, a social security number, a credit card number, any combination thereof, or any other data that can identify a user. In certain embodiments, user credentials may be the combination of a username and a password.

Once a user has entered user credentials, computer system **106** may communicate message **114** over network **112** to authentication server **116**. Message **114** may contain the attempted user credentials, or it may contain information derived from the attempted user credentials, and a request to access service **118** of provisioned computing resources environment **104**.

Network **112** facilitates wireless or wireline communication. Network **112** may communicate, for example, IP packets, Frame Relay frames, Asynchronous Transfer Mode cells, voice, video, data, and other suitable information between network addresses. Network **112** may include one or more personal area networks (PANs), local area networks (LANs), a wireless LAN (WLAN), a virtual private network (VPN), radio access networks (RANs), metropolitan area networks (MANs), wide area networks (WANs), mobile networks (e.g., using WiMax (802.16), WiFi (802.11), 3G,

or any other suitable wireless technologies in any suitable combination), all or a portion of the global computer network known as the Internet, an extranet, a satellite network, and/or any other communication system or systems at one or more locations, any of which may be any suitable combination of wireless and wireline.

In general, provisioned computing resources environment **104** (including, for example, one or more of services **118** and authentication server system **116**) provides a collection of computing services over a network (which may or may not be network **112**). Those computing services may include any suitable combination of, for example, storage, computer processing, networking, applications, power, or any other suitable computing resource that may be made available over a network. In certain embodiments, one or more of those services may be provided by service **118**. Service **118** may be any software, hardware, firmware, or combination thereof capable of providing a user with a computing service as required by particular needs. For example, service **118a** may be a database service and service **118b** may be a data storage service. In some embodiments, service **118** may comprise processor **128** and memory **130**. Processor **128** may include one or more microprocessors, controllers, or any other suitable computing devices or resources. Processor **128** may work, either alone or with components of credentials verification system **100**, to provide a portion or all of the functionality of credentials verification system **100** described herein. Processor **128** communicatively couples to memory **130**. Memory **130** may take the form of volatile or non-volatile memory including, without limitation, magnetic media, optical media, RAM, ROM, removable media, or any other suitable memory component.

In certain embodiments, memory **130** may be internal or external to processor **108** and may include one or more instruction caches or one or more data caches. Instructions in the instruction caches may be copies of instructions in memory **130**, and the instruction caches may speed up retrieval of those instructions by processor **128**. Data in the data caches may include any suitable combination of copies of data in memory **130** for instructions executing at processor **108** to operate on; the results of previous instructions executed at processor **128** for access by subsequent instructions executing at processor **128**, or for writing to memory **130**; and other suitable data. The data caches may speed up read or write operations by processor **128**.

Generally, authentication server **116** receives user credentials and determines whether a particular user's user credentials are valid. If the user credentials are valid, then authentication server **116** may confirm the user as authorized to access service **118**. Authentication server **116** also may determine if a malicious entity is attempting to gain access to provisioned computing resources environment **104** by password guessing or if a bona fide user is merely inputting incorrect user credentials. In particular, authentication server **116** comprises processor **120** and memory **122**. Processor **120** may include one or more microprocessors, controllers, or any other suitable computing devices or resources. Processor **120** may work, either alone or with components of credentials verification system **100**, to provide a portion or all of the functionality of credentials verification system **100** described herein. Processor **120** communicatively couples to memory **122**. Memory **122** may take the form of volatile or non-volatile memory including, without limitation, magnetic media, optical media, RAM, ROM, removable media, or any other suitable memory component.

In certain embodiments, memory **122** may be internal or external to processor **108** and may include one or more

instruction caches or one or more data caches. Instructions in the instruction caches may be copies of instructions in memory 122, and the instruction caches may speed up retrieval of those instructions by processor 120. Data in the data caches may include any suitable combination of copies of data in memory 122 for instructions executing at processor 120 to operate on; the results of previous instructions executed at processor 120 for access by subsequent instructions executing at processor 120, or for writing to memory 122; and other suitable data. The data caches may speed up read or write operations by processor 120. Although depicted separately and individually in FIG. 1 for illustrative purposes, the functionality and capabilities of processors 120 and 128 may be included in a single processor or multiple processors. Similarly, although memories 122 and 130 are depicted separately and individually in FIG. 1 for illustrative purposes, the functionality and capabilities of memories 122 and 130 may be included in a single memory or multiple memories.

In response to receiving message 114, authentication server 116 may facilitate communication between processor 120 and memory 122 to initiate the authentication of the attempted user credentials. In certain embodiments, authentication server 116 may initiate the authentication of the attempted user credentials by accessing user accounts 124. User accounts 124 is a collection of user credentials associated with user accounts. For example, a particular user account 124 may comprise a unique user account identifier in addition to user credentials. In certain embodiments, the unique user account identifier may be a part of the user credentials. User accounts 124 may be stored in one or more text files, tables in a relational database, or any other suitable data structure capable of storing information. Authentication server 116 may use the attempted user credentials to retrieve a particular user account 124. Authentication server 116 may then compare the attempted user credentials to the user credentials of the particular user account 124. For example, in certain embodiments, authentication server 116 may use a username in the attempted user credentials to retrieve a particular user account 124 and then compare a password in the attempted user credentials to the password associated with user account 124. If the attempted user credentials match the user credentials of user account 124, then authentication server 116 may deem the user as authenticated and grant access to service 118.

For particular attempted user credentials, authentication server 116 may store the attempted user credentials in memory 122. In the illustrated embodiment, authentication server 116 may store the attempted user credentials as part of password attempts 126. Password attempts 126 is a collection of user credentials communicated to authentication server 116. In certain embodiments, authentication server 116 may store all attempted user credentials. In certain embodiments, authentication server 116 may store only select user credentials. Attempted user credentials may be stored in one or more text files, tables in a relational database, or any other suitable data structure capable of storing information. For example, password attempts 126 may be a table in a relational database. Although the example of storing password attempts is given, any attempted user credential may be stored in password attempts 126, as required by particular needs of credentials verification system 100. In certain embodiments, the information stored in password attempts 126 may be user account identifiers, attempted user credentials, time and date of attempted user credentials, result of authentication of attempted user credentials, one or more counters 136, or any

other information that may be helpful in determining whether credentials verification system 100 is being accessed by a bona fide user or a malicious entity.

In certain embodiments, to enable authentication server 116 to scale, to improve security, and to perform well in the face of large numbers of correct and malicious users, it can be useful to store only enough information to determine whether an authentication attempt constitutes a distinct attempted credential rather than storing every authentication attempt. For example, by associating a Bloom filter with a counter for each credential verifier in credentials verification system 100, authentication server 116 can determine whether an attempted credential is new (and then insert it into the Bloom filter and increment the associated counter) in fixed space and time for an effectively unlimited number of attempted credentials. In other words, authentication server 116 may attempt to match a particular attempted credential of the authentication attempt against the Bloom filter and if the match fails, the attempted credential may be determined to be distinct and a representation of the attempted credential is stored using the Bloom filter (which may be stored in memory 122) for the associated credential verifier. If the match is successful, the representation of the attempted credential is already in the Bloom filter and need not be stored using the Bloom filter. As known by one skilled in the art, the representation of an object stored into the Bloom filter (here the attempted credential) can be generated by executing a desired number of hashes to set the appropriate bits in a bit vector of the Bloom filter. The same hashes are then applied to the attempted credentials of later authentication attempts and the resulting bits are compared to the bits that already are stored in the bit vector of the Bloom filter. If the bits match (success), then the attempted credential is likely not distinct, according to a probabilistic function, from previously attempted credentials. If the bits do not match (fail), then the attempted credential is distinct from previously attempted credentials.

In addition to storing the attempted user credentials in password attempts 126, authentication server 116 may determine whether the attempted user credentials are distinct for the particular user account 124. For example, authentication server 116 may determine whether the attempted user credentials are distinct by utilizing a Bloom filter. In certain embodiments, authentication server 116 may have counter 136 keeping track of distinct attempted user credentials for a particular user account 124. For example, counter 136 may be a field in password attempts 126. Authentication server 116 may compare the attempted user credentials against the user credentials associated with the particular account. If the attempted user credentials are distinct from the user credentials associated with the particular account, authentication server 116 may compare the attempted user credentials with other previously attempted user credentials for the particular account. In certain embodiments, if authentication server 116 determines the attempted user credentials are distinct from all previously attempted user credentials, then authentication server 116 may increment a counter 136 associated with the particular user account 124. Authentication server 116 makes the determination of whether one user credential is distinct from another user credential based on a predefined user credential policy of provisioned computing resources environment 104. For example, if the predefined user credential policy is case-sensitive, then similar user credentials of different cases, such as the words “TEST” and “test,” may be determined to be distinct. However, if the predefined user credential policy is not case-sensitive, then the user credentials of “TEST” and “test” may be determined not to be

distinct. Once authentication server **116** determines that the attempted user credentials are distinct for a particular user account **124**, authentication server **116** may increment counter **136** keeping track of distinct user credential attempts. If authentication server **116** determines that the attempted user credentials are not distinct to the correct user credentials associated with user account **124** or to previously attempted user credentials, then authentication server **116** may not increment counter **136** keeping track of distinct user credential attempts; thus counter **136** remains in its current state.

In certain embodiments, authentication server **116** may track particular attempted user credentials being attempted for distinct user accounts **124**. For example, a malicious user may have discovered a correct password, but not the particular user account **124** associated with that password. Thus, the malicious user may enter the same password for various user accounts **124**. In such embodiments, authentication server **116** may store attempted user credentials in password attempts **126** or in another data structure capable of holding information in memory **122**. For every distinct user account **124** attempted for a particular attempted user credential, authentication server **116** may increment counter **136**. If authentication server **116** determines an attempted user account **124** is not distinct to a particular attempted user credential, then authentication server **116** may not increment the counter **136** associated with the particular attempted user credential; thus the counter remains in its current state.

In certain embodiments, authentication server **116** may associate multiple counters **136** for each user account **124**. For example, there may be one counter, which is an instance counter, that keeps track of distinct attempted user credentials within a specific time period while a second counter, that is a lifetime counter, may keep track of distinct attempted user credentials over the lifetime of the particular user account **124**. An example of a counter that keeps track of distinct attempts over a specific time period may be that counter **136** keeps track of distinct attempted user credentials since the last successful authentication of a particular user account **124**. In such an embodiment, authentication server **116** may determine that particular attempted user credentials may be distinct when comparing the particular attempted user credentials with all other attempted user credentials for that particular account since the last successful authentication for that particular account, and, thus, may increment the instance counter. However, authentication server **116** may determine that the particular attempted user credentials may not be distinct when comparing the particular attempted user credentials with all other attempted user credentials for that particular account over the lifetime of that particular account. In that instance, authentication server **116** may not increment a lifetime counter, thus the counter remains in its current state. If authentication server **116** determines that the attempted user credentials match the user credentials associated with the particular user account **124**, then authentication server **116** may reset an instance counter associated with the particular user account **124**. For example, authentication sever **116** may reset the instance counter to 0.

In certain embodiments, authentication server **116** may have threshold values for counters **136** associated with user accounts **124**. For example, a threshold value may be a number predefined by an administrator of provisioned computing resources environment **104** to determine whether the attempted user credentials that are being received are from a bona fide user that may be entering the user credentials incorrectly or by a malicious entity trying to guess the

password to gain unauthorized access to provisioned computing resources environment **104**. When a certain counter **136** associated with a particular user account **124** reaches or exceeds the threshold value, then a remediation action based on a security policy may be triggered. An example of a security policy may be to lock user accounts **124** that have at least one counter **136** that has exceeded the threshold value until further action by the user is taken. Examples of further action is changing user credentials associated with user account **124**, entering information in addition to user credentials, or replying to security questions. Another example of a security policy is contacting the user associated with a particular user account **124** regarding numerous incorrect attempted user credentials. The user may be contacted via phone, email, text message, or any other method of communication. A further example of a security policy is presenting the user with a CAPTCHA test that is relatively easy for human users to solve but is difficult for computers to solve. For example, one example CAPTCHA test can require the user to input a series of text characters that are displayed in a distorted image in addition to user credentials. Requiring the user to correctly answer the CAPTCHA prompt may serve the purpose of determining whether the user is really a malicious automated entity, or a malicious human-aided entity, incapable of correctly answering a CAPTCHA test. The security policy may be any one of the previous examples, a combination of the previous examples, or any other security policy suitable for particular needs of provisioned computing resources environment **104**.

The term “user credentials” is not meant to limit a particular embodiment to a specific type or format of user credentials. Credentials verification system **100** is capable of processing any variation of user credentials in any particular operation of the example system. The present disclosure contemplates credentials verification system **100** possessing the flexibility to accommodate any combination of user credentials as required by particular needs. In certain embodiments, user credentials may be one of four varieties: credential, authentication claim, credential verifier, and credential identifier.

A credential may be user credentials that have not had any function(s) applied yet. For example, if a user has a password associated with a user account, the credential may be the actual clear text password. Certain components of credentials verification system **100** may access, communicate, store, or otherwise process user credentials as a credential. An authentication claim may be data, such as a text string, derived from attempted user credentials presented during an authentication attempt. For example, the authentication claim may be the result of applying a hash function to attempted user credentials. Certain components of credentials verification system **100** may access, communicate, store, or otherwise process user credentials as an authentication claim. A credential verifier may be data, such as a text string, that is sufficient to verify an authentication claim. A credential verifier may be the result of applying one or more functions, algorithms, routines, and/or procedures or any other suitable process according to particular needs to a credential. For example, a credential verifier may be the result of applying a second hash function to the result of applying a first hash function to the credential. The first and second hash functions may or may not be the same hash function. Certain components of credentials verification system **100** may access, communicate, store, or otherwise process user credentials as a credential verifier. In certain embodiments, credentials verification system **100** may compare some variation of attempted user credentials against the

credential verifier to determine the validity of the user credentials during authentication.

A credential identifier is the result of applying a function to the authentication claim such that for two authentication claims derived from the same credential, the credential identifiers of those two authentication claims will have the same value. For example, an authentication claim may be the result of applying a first hash function to an attempted user credential. The credential identifier may be the result of applying a second hash function to that authentication claim. The first and second hash functions may or may not be the same hash functions. Certain components of credentials verification system **100** may access, communicate, store, or otherwise process user credentials as a credential identifier. In certain embodiments, credentials verification system **100** may compare the credential identifier against a credential verifier to determine whether particular attempted user credentials are valid. According to some embodiments, credentials verification system **100** may compare a credential identifier to previously stored credential identifiers to determine whether the credential identifier is distinct from previously stored credential identifiers.

In a particular embodiment, credentials verification system **100** may receive an authentication attempt. The authentication attempt may comprise an authentication claim. The authentication claim may be the result of a function applied to attempted user credentials. Credentials verification system **100** may determine the validity of the authentication attempt by comparing the credential identifier of the authentication attempt to a stored credential verifier associated with a user account. The credential identifier may be the result of a function applied to the authentication claim. If validation of the authentication attempt succeeds, the user may be authenticated. If validation fails, credentials verification system **100** may compare the credential identifier to previously stored credential identifiers. For example, credentials verification system may use a Bloom filter to determine if the credential identifier is distinct from other credential identifiers. If credentials verification system **100** determines that the credential identifier is distinct from previously stored credential identifiers for a particular user account, credentials verification system **100** may increment an appropriate counter.

Any component of credentials verification system **100** may include an interface, logic, memory, and/or other suitable elements. An interface receives input, sends output, processes the input and/or output and/or performs other suitable operations. An interface may comprise hardware and/or software. Logic performs the operation of the component, for example, logic executes instructions to generate output from input. Logic may include hardware, software, and/or other logic. Logic may be encoded in one or more non-transitory media, such as a computer-readable medium or any other suitable tangible medium, and may perform operations when executed by a computer. Certain logic, such as a processor, may manage the operation of a component. Examples of a processor include one or more computers, one or more microprocessors, one or more applications, and/or other logic. Any suitable logic may perform the functions of credentials verification system **100**.

Certain embodiments of the present disclosure may provide some, none, or all of the following technical advantages. For example, certain embodiments can differentiate between the password guessing of a malicious entity from a bona fide user that has mistakenly entered incorrect user credentials a few times by mistake. This can provide provisioned computing resources environment **104** with

improved security and protection from malicious attacks while avoiding unnecessarily preventing bona fide users from accessing various services **118** of provisioned computing resources environment **104**. This can help prevent a bona fide user from being frustrated from being unnecessarily locked out of his or her user account. Because certain embodiments may be able to more accurately detect malicious attacks, the resources required to address potential malicious attacks will be used more sparingly, improving efficiency and cutting costs associated with securing provisioned computing resources environment **104**. Another advantage of certain embodiments is the heightened security and protection from a malicious entity learning of a correct user credential and then applying it to various user accounts to determine which account the user credentials may authorize. In certain embodiments, provisioned computing resources environment **104** may increase security by being able to detect a malicious entity that only guesses user credentials for a particular user account **124** over a prolonged period of time in hopes of avoiding triggering a time based user credential attempt limit.

FIG. **2** illustrates example attempted user credentials data, which may be used by the example systems of FIG. **1**, **4**, or **5** for differentiating between malicious password guessing and honest mistakes, according to certain embodiments of a present disclosure. Each attempted user credentials data entry corresponds to attempted user credentials. An example data set of FIG. **2** is attempted user credentials data **200**, which represents attempted user credentials logged by authentication server **116**. It should be understood that attempted user credentials data **200** is provided for example purposes only. The example attempted user credentials data **200** will be described with reference to example credentials verification system **100**. Attempted user credentials data **200** is depicted as having a tabular structure for illustrative purposes only. Attempted user credentials data **200** can be stored in a text file, a table in a relational database, a spreadsheet, a hash table, a linked list, or any other suitable data structure capable of storing information. In certain embodiments, attempted user credentials data may be stored in password attempts **126**. Each entry in attempted user credentials data **200** may or may not be assigned a unique identifier. It should be noted that although only clear text values readable by humans are shown in attempted user credentials data **200**, credentials verification system **100** is capable of accommodating a variety of formatted data values including encrypted data values for increased security.

As an example, attempted user credentials data **200** of FIG. **2** may be discussed in conjunction with various components of the example system **100** of FIG. **1**. Attempted user credentials data **200** of FIG. **2** may also be implemented in the example system **400** of FIG. **4** or the example system **500** of FIG. **5**.

Generally, attempted user credentials data **200** contains various details about attempted user credentials received by authentication server **116**. Attempted user credentials data **200** can contain any information about attempted user credentials that may be used to differentiate between malicious password guessing and honest mistakes by credentials verification system **100**. For example, attempted user credentials data **200** may contain account identifier **202**, attempted user credential **204**, timestamp **206**, result of authentication **208**, distinct counter **210**, and lifetime counter **212**. Records **214** are example entries of attempted user credentials data **200** where each record **214** corresponds to a particular attempt at using user credentials in credentials

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verification system **100**. Although nine records **214** are illustrated, attempted user credentials data **200** can contain as many or as few records **214** as required to fulfill particular needs. Similarly, although only six data elements, depicted in the current example as columns, are shown in attempted user credentials data **200**, attempted user credentials data **200** can contain as many or as few data elements are required to fulfill particular needs.

In certain embodiments, account identifier **202** is a unique identifier that references a particular user account **124**. Account identifier **202** may be a number, text string, or any other identifier capable of identifying a particular user account **124**. In the current example, records **214** all include a text string as account identifier **202**. For example, records **214a** through **214h** contain account identifier **202** for “Account1” which may be a reference to the same particular user account **124**. Record **214i** contains account identifier **202** for “Account2” which may be a reference to a different user account **124**.

In certain embodiments, attempted user credential **204** represents a user credential that may have been entered in order to request authentication in credentials verification system **100**. For example, attempted user credential **204** may be a user’s name, a username, a password, an account name, a personal identification number, a social security number, a credit card number, any combination thereof, or any other data that can identify a user. In the illustrated example, record **214a** contains attempted user credential **204** of “password” and record **214b** contains attempted user credential **204** of “PASSWORD.”

In certain embodiments, timestamp **206** represents a specific time that a particular user credential was attempted. For example, timestamp **206** may be a sequence of characters denoting a date and/or time. Timestamp **206** may be in any format for the date and/or time as require by particular needs. In certain embodiments, timestamp **206** may be formatted according to the ISO 8601 time and date format. In certain embodiments, timestamp **206** may be the number of seconds since the UNIX epoch (defined as Jan. 1, 1970) until a user credential was attempted. In the illustrated example, timestamp **206** is depicted as time formatted in a human-readable format. For example, record **214a** contains timestamp **206** of “8:03” and record **214b** contains timestamp **206** of “8:04.”

In certain embodiments, result of authentication **208** represents whether or not an attempted user credential was successfully authenticated. Examples of result of authentication **208** may be a single binary digit, a number, a single character, a string of characters, or any other result of authentication **208** that is capable of denoting successful attempted user credentials from unsuccessful user credentials. For example, in the current example, result of authentication **208** contains a single letter: the letter “N” denoting an unsuccessful user credential or the letter “Y” denoting a successful user credential. For example, record **214a** contains result of authentication **208** of “N” denoting an unsuccessful user credential attempt and record **214c** contains result of authentication **208** of “Y” denoting a successful user credential attempt.

Generally, attempted user credentials data **200** may include one or more counters to keep track of distinct attempted user credentials. In the illustrated example, attempted user credentials data **200** includes two counters: distinct counter **210** and lifetime counter **212**. In the illustrated example, distinct counter **210** may be initialized when user account **124** is created or when a first attempted user credential for a particular account is received. For example,

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distinct counter **210** may keep track of distinct attempted user credentials since the last successful attempted user credentials. For example, in the illustrated example, distinct counter **210** keeps track of distinct attempted user credential **204** since the last time result of authentication **208** was successful, or equal to “Y.” In certain embodiments, distinct counter **210** may track distinct attempted user credentials **204** since the last successful attempted user credential, within the last hour, within the last day, or any other timeframe. As an example of distinct counter **210** behavior, if a successful attempted user credential is entered for account **124**, then distinct counter **210** may be reset to zero.

In certain embodiments, lifetime counter **212** may track the total number of distinct attempted user credentials **204** since user account **124** was created. In the illustrated example, record **214a** represents a user that entered attempted user credential **204** of “password” for account identifier **202** of “Account1” at a time depicted as timestamp **206** of “8:03.” Because attempted user credential **204** was incorrect, result of authentication **208** is “N” or unsuccessful. Authentication server **116** determines that attempted user credential **204** of “password” is distinct to all previous attempted user credentials **204** for account identifier **202** since the last successful attempted user credential and increments distinct counter **210** to “1.” Authentication server **116** may also determine that attempted user credential **204** of “password” is distinct to all previous attempted user credentials **204** for account identifier **202** over the lifetime of account identifier **202** and thus increments lifetime counter **212** to “1” as well. Record **214b** is another example of an unsuccessful attempted user credential **204**. The distinct attempted user credential **204** of “PASSWORD” was entered and was determined to be unsuccessful and distinct counter **210** and lifetime counter **212** were incremented accordingly to “2.”

Record **214c** is an example illustration of record **214** with a successful attempted user credential. In the illustrated example, record **214c** represents a user that entered attempted user credential **204** of “PASSWORD 1” for account identifier **202** of “Account1” at a time depicted as timestamp **206** of “8:05.” Because attempted user credential **204** was correct, result of authentication **208** is “Y” or successful. Authentication server **116** determines that attempted user credential **204** of “PASSWORD 1” is correct for account identifier **202** and may reset distinct counter **210** to “0” but may not reset lifetime counter **212** which may remain in a current state.

Record **214d** is an example illustration of record **214** with an unsuccessful attempted user credential entered after a successful attempted user credential. In the illustrated example, record **214d** represents a user that entered attempted user credential **204** of “password” for account identifier **202** of “Account1” at a time depicted as timestamp **206** of “11:10.” Because attempted user credential **204** was incorrect, result of authentication **208** is “N” or unsuccessful. Authentication server **116** determines that attempted user credential **204** of “password” is a distinct attempted user credential **204** since the last successful attempted user credential, and increments distinct counter **210** from “0” to “1.” Authentication server **116** may determine that attempted user credential **204** of “password” is not distinct over the lifetime of account identifier **202** of “Account1” because record **214a** also had attempted user credential **204** of “password.” Thus authentication server **116** may not increment lifetime counter **212**, which may remain in a current state.

In certain embodiments, there may be a threshold value for each counter of example attempted user credentials data **200**. When a particular counter reaches its associated threshold value, then credentials verification system **100** may initiate a security policy. For example, example record **214h** has distinct counter **210** entry of “5” and lifetime counter **212** entry of “6.” An administrator of credentials verification system **100** may have preset a threshold value of five for distinct counter **210** which may trigger a security policy and a threshold value of ten for lifetime counter **212** which may trigger a different security policy. In this example, because distinct counter **210** is at “5” for record **214h**, a security policy may have been triggered. However, because the threshold value for lifetime counter **212** is ten, the lifetime counter **212** entry of “6” is not high enough to trigger the second security policy.

FIG. 3 illustrates example attempted user credentials data, which may be used by the example systems of FIG. 1, 4, or 5 for differentiating between malicious password guessing and honest mistakes, according to certain embodiments of a present disclosure. Each attempted user credentials data entry corresponds to attempted user credentials. In this illustrated example, credentials verification system **100** is tracking the same attempted user credential being entered for a variety of user accounts **124**. An example data set of FIG. 3 is attempted user credentials data **300**, which represents attempted user credentials logged by authentication server **116**. Generally, authentication server **116** uses attempted user credentials data **300** to determine if a malicious entity may have discovered a successful user credential but is trying to determine to which user account **124** the user credential is associated. It should be understood that attempted user credentials data **300** is provided for example purposes only. The example attempted user credentials data **300** will be described with reference to example credentials verification system **100**. Attempted user credentials data **300** is depicted as having a tabular structure for illustrative purposes only. Attempted user credentials data **300** can be stored in a text file, a table in a relational database, a spreadsheet, a hash table, a linked list, or any other suitable data structure capable of storing information. In certain embodiments, attempted user credentials data **300** may be stored in password attempts **126**. Each entry in attempted user credentials data **300** may or may not be assigned a unique identifier. It should be noted that although only clear text values readable by humans are shown in attempted user credentials data **300**, credentials verification system **100** is capable of accommodating a variety of formatted data values including encrypted data values for increased security.

As an example, attempted user credentials data **300** of FIG. 3 may be discussed in conjunction with various components of the example system **100** of FIG. 1. Attempted user credentials data **300** of FIG. 3 may also be implemented in the example system **400** of FIG. 4 or the example system **500** of FIG. 5.

Generally, attempted user credentials data **300** contains various details about attempted user credentials received by authentication server **116**. Attempted user credentials data **300** can contain any information about attempted user credentials that may be used to differentiate between malicious password guessing and honest mistakes by credentials verification system **100**. For example, attempted user credentials data **300** may contain attempted user credential **302**, account identifier **304**, timestamp **306**, result of authentication **308**, and distinct counter **310**. Records **312** are example entries of attempted user credentials data **300** where each

record **312** corresponds to a particular attempt at using user credentials in credentials verification system **100**. Although nine records **312** are illustrated, attempted user credentials data **300** can contain as many or as few records **312** as required to fulfill particular needs. Similarly, although only five data elements, depicted in the current example as columns, are shown in attempted user credentials data **300**, attempted user credentials data **300** can contain as many or as few data elements are required to fulfill particular needs.

In certain embodiments, attempted user credential **302** represents a user credential that may have been entered in order to request authentication in credentials verification system **100**. For example, attempted user credential **302** may be a user’s name, a username, a password, an account name, a personal identification number, a social security number, a credit card number, any combination thereof, or any other data that can identify a user. In the illustrated example, record **312a** contains attempted user credential **302** of “HOUSTON.” Records **312b** through **312i** all also contain attempted user credential **302** of “HOUSTON.”

In certain embodiments, account identifier **304** is a unique identifier that references a particular user account **124**. Account identifier **304** may be a number, text string, or any other identifier capable of identifying a particular user account **124**. In the current example, records **312** all include a text string as account identifier **304**. For example, record **312a** contains account identifier **304** for “Account1” which may be a reference to a particular user account **124**. Record **312b** contains account identifier **304** for “Account2” which may be a reference to a different user account **124**. Records **312f** and **312g** contain the same account identifier of “Account6.”

In certain embodiments, timestamp **306** represents a specific time that a particular user credential was attempted. For example, timestamp **306** may be a sequence of characters denoting a date and/or time. Timestamp **306** may be in any format for the date and/or time as required by particular needs. In certain embodiments, timestamp **306** may be formatted according to the ISO 8601 time and date format. In certain embodiments, timestamp **306** may be the number of seconds since the UNIX epoch (defined as Jan. 1, 1970) until a user credential was attempted. In the illustrated example, timestamp **306** is depicted as time formatted in a human-readable format. For example, record **312a** contains timestamp **306** of “8:03” and record **312b** contains timestamp **306** of “8:04.”

In certain embodiments, result of authentication **308** represents whether or not an attempted user credential **302** was successfully authenticated. Examples of result of authentication **308** may be a single binary digit, a number, a single character, a string of characters, or any other result of authentication **308** that is capable of denoting successful attempted user credentials from unsuccessful user credentials. For example, in the current example, result of authentication **308** contains a single letter: the letter “N” denoting an unsuccessful user credential or the letter “Y” denoting a successful user credential. For example, record **312a** through **312i** all contain result of authentication **308** of “N” denoting an unsuccessful user credential.

Generally, attempted user credentials data **300** may include one or more counters to keep track of distinct attempted user credentials. In the illustrated example, attempted user credentials data **300** includes one counter: distinct counter **310**. In the illustrated example, distinct counter **310** may be initialized when the first record **312** for a particular attempted user credential **302** is created. Distinct counter **310** may keep track of distinct attempted account



identifiers **304** for a particular attempted user credential **302**. For example, in the illustrated example, distinct counter **310** keeps track of distinct account identifiers **304** for which attempted user credential **302** of "HOUSTON" was entered. In certain embodiments, distinct counter **310** may track distinct attempted account identifiers **304** for a particular attempted user credential **302** since the last successful attempted user credential, within the last hour, within the last day, or any other timeframe. For example, if a successful attempted user credential is entered for account **124**, then distinct counter **310** may be reset to zero.

In the illustrated example, in record **312a**, attempted user credential **302** of "HOUSTON" is attempted for account identifier **304** of "Account1" at timestamp **306** of "8:03." Authentication server **116** may determine that account identifier **304** is distinct for attempted user credential **302** of "HOUSTON" and may increment distinct counter **310** for record **312a** to "1." Records **312b** through **312f** exemplify a similar process where attempted user credential **302** of "HOUSTON" was attempted for distinct account identifiers **304** and distinct counter **310** was incremented each time. In the illustrated example, in record **312g** attempted user credential **302** of "HOUSTON" is attempted for account identifier **304** of "Account6" at timestamp **306** of "11:13." However, because record **312f** indicates that user credential **302** of "HOUSTON" was already entered for account identifier **304** of "Account6," authentication server **116** may conclude that attempted user credential **302** in record **312g** is not distinct and thus distinct counter for record **312g** is not incremented, remaining in the current state of "6." Example records **312h** and **312i** are further examples of where credential **302** of "HOUSTON" was entered for distinct account identifiers **304**.

In certain embodiments, there may be a threshold value for each counter of example attempted user credentials data **300**. When a particular counter reaches its associated threshold value, then credentials verification system **100** may initiate a security policy. For example, example record **312i** has distinct counter **310** entry of "8." An administrator of credentials verification system **100** may have preset a threshold value of ten for distinct counter **310** which may trigger a security policy. In this example, because distinct counter **310** is at "8" for record **312i**, a security policy may not have been triggered. However, if the threshold value instead was eight, then a security policy would have been triggered.

FIG. 4 illustrates an example system for differentiating between malicious password guessing and honest mistakes. In the illustrated example credentials verification system **400** includes automated teller machine (ATM) **404** and authentication server **408**. Although credentials verification system **400** is illustrated and primarily described as including particular components, the present disclosure contemplates credentials verification system **400** including any suitable components, according to particular needs.

Generally, credentials verification system **400** may be comprised of ATM **404** and authentication server **408**. User **402** may attempt authentication at ATM **404**. Therefore, user **402** may have to enter user credentials in ATM **404** before being granted access to various services. Although ATM **404** is depicted as an example for credentials verification system **400**, credentials verification system **400** may be used in any environment where a user is requesting authentication for access to a service at a remote terminal.

ATM **404** may be any ATM **404** that is capable of taking the input of user credentials from user **402** and attempting to provide a service after authenticating user **402**. For example, ATM **404** may have one or more processors, one or more

memories, one or more displays, one or more keypads, one or more card readers, one or more network interfaces, or any other component useful for authenticating user **402**.

User **402** may use various components of ATM **404** to enter user credentials to be authenticated before being granted access to particular services. User credentials may be any data that can identify a particular user **402** to ATM **404**. For example, a user credential may be the user's name, a username, a password, an account name, an account number from an ATM card, a personal identification number, a social security number, a credit card number, any combination thereof, or any other data that can identify user **402**. As described above in the detailed description of FIG. 1, in some embodiments, user credentials may be one of four varieties: credential, authentication claim, credential verifier, and credential identifier. In certain embodiments, user credentials may be the combination of a personal identification number and a user account number.

Once user **402** has entered user credentials, ATM **404** may communicate message **418** over network **406** to authentication server **408**. Message **418** may contain the attempted user credentials, or it may contain information derived from the attempted user credentials, and a request to access a particular service of ATM **404**.

Network **406** facilitates wireless or wireline communication. Network **406** may communicate, for example, IP packets, Frame Relay frames, Asynchronous Transfer Mode cells, voice, video, data, and other suitable information between network addresses. Network **406** may include one or more personal area networks (PANs), local area networks (LANs), a wireless LAN (WLAN), a virtual private network (VPN), radio access networks (RANs), metropolitan area networks (MANs), wide area networks (WANs), mobile networks (e.g., using WiMax (802.16), WiFi (802.11), 3G, or any other suitable wireless technologies in any suitable combination), all or a portion of the global computer network known as the Internet, an extranet, a satellite network, and/or any other communication system or systems at one or more locations, any of which may be any suitable combination of wireless and wireline.

Generally, authentication server **408** receives user credentials and determines whether the user credentials are correct for the particular user **402**. If the user credentials are correct, then authentication server **408** may confirm user **402** as authorized. Authentication server **408** also may determine if a malicious entity is attempting to gain access to ATM **404** by password guessing or if a bona fide user is merely inputting incorrect user credentials. In particular, authentication server **408** comprises processor **410** and memory **412**. Processor **410** may include one or more microprocessors, controllers, or any other suitable computing devices or resources. Processor **410** may work, either alone or with components of credentials verification system **400**, to provide a portion or all of the functionality of credentials verification system **400** described herein. Processor **410** communicatively couples to memory **412**. Memory **412** may take the form of volatile or non-volatile memory including, without limitation, magnetic media, optical media, RAM, ROM, removable media, or any other suitable memory component.

In certain embodiments, memory **412** may be internal or external to processor **410** and may include one or more instruction caches or one or more data caches. Instructions in the instruction caches may be copies of instructions in memory **412**, and the instruction caches may speed up retrieval of those instructions by processor **410**. Data in the data caches may include any suitable combination of copies

of data in memory 412 for instructions executing at processor 410 to operate on; the results of previous instructions executed at processor 410 for access by subsequent instructions executing at processor 410, or for writing to memory 412; and other suitable data. The data caches may speed up read or write operations by processor 410.

In response to receiving message 418, authentication server 408 may facilitate communication between processor 410 and memory 412 to initiate the authentication of the attempted user credentials. In certain embodiments, authentication server 408 may initiate the authentication of the attempted user credentials by accessing user accounts 414. User accounts 414 is a collection of user credentials associated with user accounts, each user account associated with a particular user 402. For example, a particular user account 414 may comprise a unique user account identifier in addition to user credentials. In certain embodiments, the unique user account identifier may be a part of the user credentials. User accounts 414 may be stored in one or more text files, tables in a relational database, or any other suitable data structure capable of storing information. Authentication server 408 may use the attempted user credentials to retrieve a particular user account 414. Authentication server 408 may then compare the attempted user credentials to the user credentials of particular user account 414. For example, in certain embodiments, authentication server 408 may use an account number in the attempted user credentials to retrieve a particular user account 414 and then compare a personal identification number in the attempted user credentials to the personal identification number associated with user account 414. If the attempted user credentials match the user credentials of user account 414, then authentication server 408 may deem user 402 as authenticated and grant access to the services of ATM 404.

For particular attempted user credentials, authentication server 408 may store the attempted user credentials in memory 412. In the illustrated embodiment, authentication server 408 may store the attempted user credentials as part of password attempts 416. Password attempts 416 is a collection of user credentials communicated to authentication server 408. In certain embodiments, authentication server 408 may store every attempted user credential. In certain embodiments, authentication server 408 may store only select user credentials. Attempted user credentials may be stored in one or more text files, tables in a relational database, or any other suitable data structure capable of storing information. For example, password attempts 416 may be a table in a relational database. Although the example of storing password attempts is given, any attempted user credential may be stored in password attempts 416, as required by particular needs of credentials verification system 400. In certain embodiments, the information stored in password attempts 416 may be user account identifiers, attempted user credentials, time and date of attempted user credentials, result of authentication of attempted user credentials, one or more counters, or any other information that may be helpful in determining whether credentials verification system 400 is being accessed by a bona fide user or a malicious entity.

In addition to storing the attempted user credentials in password attempts 416, authentication server 408 may determine whether the attempted user credentials are distinct for the particular user account 414. For example, authentication server 408 may determine whether the attempted user credentials are distinct by utilizing a Bloom Filter. In certain embodiments, authentication server 408 may have counter 420 keeping track of distinct attempted user credentials for

a particular user account 414. For example, counter 420 may be a field in password attempts 416. Authentication server 408 may compare the attempted user credentials against the user credentials associated with the particular account. If the attempted user credentials are distinct from the user credentials associated with the particular account, authentication server 408 may compare the attempted user credentials with other previously attempted user credentials for a particular account. In certain embodiments, if authentication server 408 determines the attempted user credentials are distinct from all previously attempted user credentials, then authentication server 408 may increment counter 420 associated with the particular user account 414. Authentication server 408 makes the determination of whether one user credential is distinct from another user credential based on a predefined user credential policy of credentials verification system 400. For example, if the predefined user credential policy is case-sensitive, then similar user credentials of different cases, such as the words "TEST" and "test," may be determined to be distinct. However, if the predefined user credential policy is not case-sensitive, then the user credentials of "TEST" and "test" may be determined not to be distinct. Once authentication server 408 determines that the attempted user credentials are distinct for a particular user account 414, authentication server 408 may increment counter 420 keeping track of distinct user credential attempts. If authentication server 408 determines that the attempted user credentials are not distinct to the correct user credentials associated with user account 414 or to previously attempted user credentials, then authentication server 408 may not increment counter 420 keeping track of distinct user credential attempts, thus counter 420 remains in its current state.

In certain embodiments authentication server 408 may track particular attempted user credentials being attempted for distinct user accounts 414. For example, a malicious user may have discovered a correct personal identification number, but not the particular user account 414 associated with that personal identification number. Thus, the malicious user may enter the same personal identification number for various user accounts 414. In such embodiments, authentication server 408 may store attempted user credentials in password attempts 416 or in another data structure capable of holding information in memory 412. For every distinct user account 414 attempted for a particular attempted user credential, authentication server 408 may increment counter 420. If authentication server 408 determines an attempted user account 414 is not distinct to a particular attempted user credential, then authentication server 408 may not increment the counter 420 associated with the particular attempted user credential, thus counter 420 remains in its current state.

In certain embodiments, authentication server 408 may associate multiple counters 420 for each user account 414. For example, there may be one counter 420, which is an instance counter 420, that keeps track of distinct attempted user credentials within a specific time period while a second counter 420, that is a lifetime counter 420, may keep track of distinct attempted user credentials over the lifetime of the particular user account 414. An example of a specific time period may be counter 420 that keeps track of distinct attempted user credentials since the last successful authentication of a particular user account 414. In such an embodiment, authentication server 408 may determine that particular attempted user credentials may be distinct when comparing the particular attempted user credentials with all other attempted user credentials for that particular account since the last successful authentication for that particular

account, and, thus, may increment instance counter 420. However, authentication server 408 may determine that the particular attempted user credentials may not be distinct when comparing the particular attempted user credentials with all other attempted user credentials for that particular account over the lifetime of that particular account. In that instance, authentication server 408 may not increment lifetime counter 420, thus counter 420 remains in its current state. If authentication server 408 determines that the attempted user credentials match the user credentials associated with the particular user account 414, then authentication server 408 may reset instance counter 420 associated with the particular user account 414. For example, authentication sever 408 may reset instance counter 420 to 0. In certain embodiments, authentication server 408 may have threshold values for counters 420 associated with user accounts 414. For example, a threshold value may be a number predefined by an administrator of credentials verification system 400 to determine whether the attempted user credentials that are being received are from a bona fide user that may be entering the user credentials incorrectly or by a malicious entity trying to guess the password to gain unauthorized access to credentials verification system 400. When a certain counter 420 associated with a particular user account 414 reaches or exceeds the threshold value, then a remediation action based on a security policy may be triggered. An example of a security policy may be to lock user accounts 414 that have at least one counter 420 that has exceeded the threshold value until further action is taken. Examples of further action is changing user credentials associated with user account 414, entering information in addition to user credentials, or replying to security questions. Another example of a security policy is contacting user 402 associated with a particular user account 414 regarding numerous incorrect attempted user credentials. User 402 may be contacted via phone, email, text message, or any other method of communication. A further example of a security policy is presenting user 402 with a CAPTCHA test that, for example, requires user 402 to input a series of text characters displayed in an image in addition to user credentials. Requiring user 402 to correctly answer the CAPTCHA test may serve the purpose of determining whether user 402 is really a malicious automated entity, or a malicious human-aided entity, incapable of correctly answering a CAPTCHA test. The security policy may be any one of the previous examples, a combination of the previous examples, or any other security policy suitable for particular needs of credentials verification system 400.

Any component of credentials verification system 400 may include an interface, logic, memory, and/or other suitable elements. An interface receives input, sends output, processes the input and/or output and/or performs other suitable operations. An interface may comprise hardware and/or software. Logic performs the operation of the component, for example, logic executes instructions to generate output from input. Logic may include hardware, software, and/or other logic. Logic may be encoded in one or more non-transitory media, such as a computer-readable medium or any other suitable tangible medium, and may perform operations when executed by a computer. Certain logic, such as a processor, may manage the operation of a component. Examples of a processor include one or more computers, one or more microprocessors, one or more applications, and/or other logic. Any suitable logic may perform the functions of credentials verification system 400.

Certain embodiments of the present disclosure may provide some, none, or all of the following technical advan-

tages. For example, certain embodiments can differentiate between the password guessing of a malicious entity from a bona fide user that has mistakenly entered incorrect user credentials a few times by mistake. This can provide credentials verification system 400 with improved security and protection from malicious attacks while avoiding unnecessarily preventing bona fide users from accessing various services of ATM 404. This can help prevent a bona fide user from being frustrated from being unnecessarily locked out of his or her user account. Because certain embodiments may be able to more accurately detect malicious attacks, the resources required to address potential malicious attacks will be used more sparingly, improving efficiency and cutting costs associated with securing credentials verification system 400. Another advantage of certain embodiments is the heightened security and protection from a malicious entity learning of a correct user credential and then applying it to various user accounts to determine which account the user credentials may authorize. In certain embodiments, credentials verification system 400 may increase security by being able to detect a malicious entity that only guesses user credentials for a particular user account 414 over a prolonged period of time in hopes of avoiding triggering a time based user credential attempt limit. In certain embodiments, authentication server 408 may perform the same or similar functions as authentication server 116.

FIG. 5 illustrates an example system for differentiating between malicious password guessing and honest mistakes. In the illustrated example, credentials verification system 500 includes security system 504 and authentication server 508. Although credentials verification system 500 is illustrated and primarily described as including particular components, the present disclosure contemplates credentials verification system 500 including any suitable components, according to particular needs.

Generally, credentials verification system 500 may be comprised of security system 504 and authentication server 508. User 502 may attempt authentication at security system 504. Therefore, user 502 may have to enter user credentials in security system 504 before being granted access to various services. For example, user 502 may be trying to gain entry into a building through a secured door. Although security system 504 is depicted as an example for credentials verification system 500, credentials verification system 500 may be used in any environment where a user is requesting authentication for access to a service or location via a remote terminal.

Security system 504 may be any security system 504 that is capable of taking the input of user credentials from user 502 and attempting to provide a service after authenticating user 502. For example, security system 504 may have one or more processors, one or more memories, one or more displays, one or more keypads, one or more card readers, one or more network interfaces, or any other component useful for authenticating user 502.

User 502 may use various components of security system 504 to enter user credentials to be authenticated before being granted access to particular services. User credentials may be any data that can identify a particular user 502 to security system 504. For example, a user credential may be the user's name, a username, a password, an account name, an account number from an access card, a personal identification number, a social security number, a credit card number, any combination thereof, or any other data that can identify user 502. As described above in the detailed description of FIG. 1, in some embodiments, user credentials may be one of four varieties: credential, authentication claim, credential veri-

fier, and credential identifier. In certain embodiments, user credentials may be the combination of a personal identification number and an account number.

Once user **502** has entered user credentials, security system **504** may communicate message **518** over network **506** to authentication server **508**. Message **518** may contain the attempted user credentials, or it may contain information derived from the attempted user credentials, and a request to access a particular service of security system **504**.

Network **506** facilitates wireless or wireline communication. Network **506** may communicate, for example, IP packets, Frame Relay frames, Asynchronous Transfer Mode cells, voice, video, data, and other suitable information between network addresses. Network **506** may include one or more personal area networks (PANs), local area networks (LANs), a wireless LAN (WLAN), a virtual private network (VPN), radio access networks (RANs), metropolitan area networks (MANs), wide area networks (WANs), mobile networks (e.g., using WiMax (802.16), WiFi (802.11), 3G, or any other suitable wireless technologies in any suitable combination), all or a portion of the global computer network known as the Internet, an extranet, a satellite network, and/or any other communication system or systems at one or more locations, any of which may be any suitable combination of wireless and wireline.

Generally, authentication server **508** receives user credentials and determines whether the user credentials are correct for the particular user **502**. If the user credentials are correct, then authentication server **508** may confirm user **502** as authorized credentials verification system **500**. Authentication server **508** also may determine if a malicious entity is attempting to gain access to security system **504** by password guessing or if a bona fide user is merely inputting incorrect user credentials. In particular, authentication server **508** comprises processor **510** and memory **512**. Processor **510** may include one or more microprocessors, controllers, or any other suitable computing devices or resources. Processor **510** may work, either alone or with components of credentials verification system **500**, to provide a portion or all of the functionality of credentials verification system **500** described herein. Processor **510** communicatively couples to memory **512**. Memory **512** may take the form of volatile or non-volatile memory including, without limitation, magnetic media, optical media, RAM, ROM, removable media, or any other suitable memory component.

In certain embodiments, memory **512** may be internal or external to processor **510** and may include one or more instruction caches or one or more data caches. Instructions in the instruction caches may be copies of instructions in memory **512**, and the instruction caches may speed up retrieval of those instructions by processor **510**. Data in the data caches may include any suitable combination of copies of data in memory **512** for instructions executing at processor **510** to operate on; the results of previous instructions executed at processor **510** for access by subsequent instructions executing at processor **510**, or for writing to memory **512**; and other suitable data. The data caches may speed up read or write operations by processor **510**.

In response to receiving message **518**, authentication server **508** may facilitate communication between processor **510** and memory **512** to initiate the authentication of the attempted user credentials. In certain embodiments, authentication server **508** may initiate the authentication of the attempted user credentials by accessing user accounts **514**. User accounts **514** is a collection of user credentials associated with user accounts, each user account associated with a particular user **502**. For example, a particular user account

**514** may comprise a unique user account identifier in addition to user credentials. In certain embodiments, the unique user account identifier may be a part of the user credentials. User accounts **514** may be stored in one or more text files, tables in a relational database, or any other suitable data structure capable of storing information. Authentication server **508** may use the attempted user credentials to retrieve a particular user account **514**. Authentication server **508** may then compare the attempted user credentials to the user credentials of particular user account **514**. For example, in certain embodiments, authentication server **508** may use an account number in the attempted user credentials to retrieve a particular user account **514** and then compare a personal identification number in the attempted user credentials to the personal identification number associated with user account **514**. If the attempted user credentials match the user credentials of user account **514**, then authentication server **508** may deem user **502** as authenticated and grant access to the services of security system **504**.

For particular attempted user credentials, authentication server **508** may store the attempted user credentials in memory **512**. In the illustrated embodiment, authentication server **508** may store the attempted user credentials as part of password attempts **516**. Password attempts **516** is a collection of user credentials communicated to authentication server **508**. In certain embodiments, authentication server **508** may store every attempted user credential. In certain embodiments, authentication server **508** may store only select user credentials. Attempted user credentials may be stored in one or more text files, tables in a relational database, or any other suitable data structure capable of storing information. For example, password attempts **516** may be a table in a relational database. Although the example of storing password attempts is given, any attempted user credential may be stored in password attempts **516**, as required by particular needs of credentials verification system **500**. In certain embodiments, the information stored in password attempts **516** may be user account identifiers, attempted user credentials, time and date of attempted user credentials, result of authentication of attempted user credentials, one or more counters **520**, or any other information that may be helpful in determining whether credentials verification system **500** is being accessed by a bona fide user or a malicious entity.

In addition to storing the attempted user credentials in password attempts **516**, authentication server **508** may determine whether the attempted user credentials are distinct for the particular user account **514**. For example, authentication server **508** may determine whether the attempted user credentials are distinct by utilizing a Bloom Filter. In certain embodiments, authentication server **508** may have a counter **520** keeping track of distinct attempted user credentials for a particular user account **514**. For example, counter **520** may be a field in password attempts **516**. Authentication server **508** may compare the attempted user credentials against the user credentials associated with the particular account. If the attempted user credentials are distinct from the user credentials associated with the particular account, authentication server **508** may compare the attempted user credentials with other previously attempted user credentials for a particular account. In certain embodiments, if authentication server **508** determines the attempted user credentials are distinct from all previously attempted user credentials, then authentication server **508** may increment a counter **520** associated with the particular user account **514**. Authentication server **508** makes the determination of whether one user credential is distinct from another user credential based on a predefined

user credential policy of credentials verification system **500**. For example, if the predefined user credential policy is case-sensitive, then similar user credentials of different cases, such as the words “TEST” and “test,” may be determined to be distinct. However, if the predefined user credential policy is not case-sensitive, then the user credentials of “TEST” and “test” may be determined not to be distinct. Once authentication server **508** determines that the attempted user credentials are distinct for a particular user account **514**, authentication server **508** may increment the counter **520** keeping track of distinct user credential attempts. If authentication server **508** determines that the attempted user credentials are not distinct to the correct user credentials associated with user account **514** or to previously attempted user credentials, then authentication server **508** may not increment the counter **520** keeping track of distinct user credential attempts, thus counter **520** remains in its current state.

In certain embodiments authentication server **508** may track particular attempted user credentials being attempted for distinct user accounts **514**. For example, a malicious user may have discovered a correct personal identification number, but not the particular user account **514** associated with that personal identification number. Thus, the malicious user may enter the same personal identification number for various user accounts **514**. In such embodiments, authentication server **508** may store attempted user credentials in password attempts **516** or in another data structure capable of holding information in memory **512**. For every distinct user account **514** attempted for a particular attempted user credential, authentication server **508** may increment counter **520**. If authentication server **508** determines an attempted user account **514** is not distinct to a particular attempted user credential, then authentication server **508** may not increment the counter **520** associated with the particular attempted user credential, thus counter **520** remains in its current state.

In certain embodiments, authentication server **508** may associate multiple counters **520** for each user account **514**. For example, there may be one counter **520**, which is an instance counter **520**, that keeps track of distinct attempted user credentials within a specific time period while a second counter **520**, that is a lifetime counter **520**, may keep track of distinct attempted user credentials over the lifetime of the particular user account **514**. An example of a specific time period may be a counter **520** that keeps track of distinct attempted user credentials since the last successful authentication of a particular user account **514**. In such an embodiment, authentication server **508** may determine that particular attempted user credentials may be distinct when comparing the particular attempted user credentials with all other attempted user credentials for that particular account since the last successful authentication for that particular account, and, thus, may increment instance counter **520**. However, authentication server **508** may determine that the particular attempted user credentials may not be distinct when comparing the particular attempted user credentials with all other attempted user credentials for that particular account over the lifetime of that particular account. In that instance, authentication server **508** may not increment lifetime counter **520**, thus counter **520** remains in its current state. If authentication server **508** determines that the attempted user credentials match the user credentials associated with the particular user account **514**, then authentication server **508** may reset instance counter **520** associated with the particular user account **514**. For example, authentication sever **508** may reset instance counter **520** to 0.

In certain embodiments, authentication server **508** may have threshold values for counters **520** associated with user accounts **514**. For example, a threshold value may be a number predefined by an administrator of credentials verification system **500** to determine whether the attempted user credentials that are being received are from a bona fide user that may be entering the user credentials incorrectly or by a malicious entity trying to guess the password to gain unauthorized access to credentials verification system **500**. When a certain counter **520** associated with a particular user account **514** reaches or exceeds the threshold value, then a remediation action based on a security policy may be triggered. An example of a security policy may be to lock user accounts **514** that have at least one counter **520** that has exceeded the threshold value until further action is taken. Examples of further action is changing user credentials associated with user account **514**, entering information in addition to user credentials, or replying to security questions. Another example of a security policy is contacting user **502** associated with a particular user account **514** regarding numerous incorrect attempted user credentials. User **502** may be contacted via phone, email, text message, or any other method of communication. A further example of a security policy is presenting user **502** with a CAPTCHA test that, for example, requires user **502** to input a series of text characters displayed in an image in addition to user credentials. Requiring user **502** to correctly answer the CAPTCHA test may serve the purpose of determining whether user **502** is really a malicious automated entity, or a malicious human-aided entity, incapable of correctly answering a CAPTCHA test. The security policy may be any one of the previous examples, a combination of the previous examples, or any other security policy suitable for particular needs of credentials verification system **500**.

Any component of credentials verification system **500** may include an interface, logic, memory, and/or other suitable elements. An interface receives input, sends output, processes the input and/or output and/or performs other suitable operations. An interface may comprise hardware and/or software. Logic performs the operation of the component, for example, logic executes instructions to generate output from input. Logic may include hardware, software, and/or other logic. Logic may be encoded in one or more non-transitory media, such as a computer-readable medium or any other suitable tangible medium, and may perform operations when executed by a computer. Certain logic, such as a processor, may manage the operation of a component. Examples of a processor include one or more computers, one or more microprocessors, one or more applications, and/or other logic. Any suitable logic may perform the functions of credentials verification system **500**.

Certain embodiments of the present disclosure may provide some, none, or all of the following technical advantages. For example, certain embodiments can differentiate between the password guessing of a malicious entity from a bona fide user that has mistakenly entered incorrect user credentials a few times by mistake. This can provide credentials verification system **500** with improved security and protection from malicious attacks while avoiding unnecessarily preventing bona fide users from accessing various services of security system **504**. This can help prevent a bona fide user from being frustrated from being unnecessarily locked out of his or her user account. Because certain embodiments may be able to more accurately detect malicious attacks, the resources required to address potential malicious attacks will be used more sparingly, improving efficiency and cutting costs associated with securing creden-

tials verification system **500**. Another advantage of certain embodiments is the heightened security and protection from a malicious entity learning of a correct user credential and then applying it to various user accounts to determine which account the user credentials may authorize. In certain 5 embodiments, credentials verification system **500** may increase security by being able to detect a malicious entity that only guesses user credentials for a particular user account **514** over a prolonged period of time in hopes of avoiding triggering a time based user credential attempt limit. In certain embodiments, authentication server **508** may perform the same or similar functions as authentication server **116**.

FIG. **6** illustrates an example method for differentiating between malicious password guessing and honest mistakes which may be performed by the example system **100** of FIG. **1** according to certain embodiments of a present disclosure. The method may be implemented in any suitable combination of software, firmware, and hardware. Although particular components may be identified as performing particular steps, the present disclosure contemplates any suitable components performing the steps according to particular needs. The same or similar methods as the example method of FIG. **6** can be performed by example the embodiments of FIGS. **4** and **5**.

As an example, the example method of FIG. **6** will be discussed in conjunction with various components of the example system **100** of FIG. **1**. The example method of FIG. **6** may also be implemented in the example system **400** of FIG. **4** or the example system **500** of FIG. **5**.

At step **600**, a user may use various components of computer **106** to enter user credentials to be authenticated before being granted access to services **118**. For example, GUI **134** of computer **106** may display a prompt to the user to enter user credentials. User credentials may be any data that can identify a particular user to provisioned computing resources environment **104**. For example, a user credential may be the user's name, a username, a password, an account name, a personal identification number, a social security number, a credit card number, any combination thereof, or any other data that can identify a user. In certain embodiments, user credentials may be the combination of a username and a password. Once a user has entered user credentials, computer system **106** may communicate message **114** over network **112** to authentication server **116**. Message **114** may contain the attempted user credentials, or it may contain information derived from the attempted user credentials, and a request to access service **118** of provisioned computing resources environment **104**.

At step **602**, authentication server **116** may store the attempted user credentials in memory **122**. In the illustrated embodiment, authentication server **116** may store the attempted user credentials as part of password attempts **126**. Password attempts **126** is a collection of user credentials communicated to authentication server **116**. In certain 55 embodiments, authentication server **116** may store every attempted user credential. In certain embodiments, authentication server **116** may store only select user credentials. Attempted user credentials may be stored in one or more text files, tables in a relational database, or any other suitable data structure capable of storing information. For example, password attempts **126** may be a table in a relational database. Although the example of storing password attempts is given, any attempted user credential may be stored in password attempts **126**, as required by particular needs of credentials verification system **100**. In certain 65 embodiments, the information stored in password attempts

**126** may be user account identifiers, attempted user credentials, time and date of attempted user credentials, result of authentication of attempted user credentials, one or more counters **136**, or any other information that may be helpful in determining whether credentials verification system **100** is being accessed by a bona fide user or a malicious entity.

At step **604**, authentication server **116** may determine if any counters **136** need to be initialized. For example, a particular counter **136** that authentication server **116** needs to access may not currently exist or it may not contain a value, therefore authentication server **116** may create it and/or assign it an initial value of zero.

At step **606**, in response to receiving message **114**, authentication server **116** may facilitate communication between processor **120** and memory **122** to initiate the authentication of the attempted user credentials. In certain embodiments, authentication server **116** may initiate the authentication of the attempted user credentials by accessing user accounts **124**. User accounts **124** is a collection of user credentials associated with user accounts. For example, a particular user account **124** may comprise a unique user account identifier in addition to user credentials. In certain 20 embodiments, the unique user account identifier may be a part of the user credentials. User accounts **124** may be stored in one or more text files, tables in a relational database, or any other suitable data structure capable of storing information. Authentication server **116** may use the attempted user credentials to retrieve a particular user account **124**. Authentication server **116** may then compare the attempted user credentials to the user credentials of particular user account **124**. For example, in certain embodiments, authentication server **116** may use a username in the attempted user credentials to retrieve a particular user account **124** and then compare a password in the attempted user credentials to the password associated with user account **124**. If the attempted user credentials match the user credentials of user account **124**, then authentication server **116** may deem the user as authenticated and the example method may proceed to step **620**. Otherwise, the example method may proceed to step **608**.

At step **608**, authentication server **116** may determine whether the attempted user credentials are distinct for the particular user account **124**. In certain embodiments, authentication server **116** may have a counter **136** keeping track of distinct attempted user credentials for a particular user account **124**. For example, counter **136** may be a field in password attempts **126**. Authentication server **116** may compare the attempted user credentials against the user credentials associated with the particular account. If the attempted user credentials are distinct from the user credentials associated with the particular account, authentication server **116** may compare the attempted user credentials with other previously attempted user credentials for a particular account. Authentication server **116** makes the determination of whether one user credential is distinct from another user credential based on a predefined user credential policy of provisioned computing resources environment **104**. For example, if the predefined user credential policy is case-sensitive, then similar user credentials of different cases, such as the words "TEST" and "test," may be determined to be distinct. However, if the predefined user credential policy is not case-sensitive, then the user credentials of "TEST" and "test" may be determined not to be distinct. Once authentication server **116** determines that the attempted user credentials are distinct for a particular user account **124**, example system may proceed to step **610**. If authentication server **116** determines that the attempted user credentials are

not distinct to the correct user credentials associated with user account 124 or to previously attempted user credentials, then authentication server 116 may not increment the counter 136 keeping track of distinct user credential attempts, thus counter 136 remains in its current state and example method proceeds to step 612.

At step 610, authentication server 116 may increment the counter 136 keeping track of distinct user credential attempts.

At step 612, in certain embodiments authentication server 116 may track particular attempted user credentials being attempted for distinct user accounts 124. For example, a malicious user may have discovered a correct password, but not the particular user account 124 associated with that password. Thus, the malicious user may enter the same password for various user accounts 124. In such embodiments, authentication server 116 may store attempted user credentials in password attempts 126 or in another data structure capable of holding information in memory 122. If authentication server 116 determines an attempted user account 124 is not distinct to a particular attempted user credential, then authentication server 116 may not increment the counter 136 associated with the particular attempted user credential, thus counter 136 remains in its current state and example method proceeds to step 616. Else, example method proceeds to step 614. At step 614, for every distinct user account 124 attempted for a particular attempted user credential, authentication server 116 may increment counter 136.

In certain embodiments, authentication server 116 may associate multiple counters 136 for each user account 124. For example, there may be one counter 136, which is an instance counter 136, that keeps track of distinct attempted user credentials within a specific time period while a second counter 136, that is a lifetime counter 136, may keep track of distinct attempted user credentials over the lifetime of the particular user account 124. An example of a specific time period may be a counter 136 that keeps track of distinct attempted user credentials since the last successful authentication of a particular user account 124. In such an embodiment, authentication server 116 may determine that particular attempted user credentials may be distinct when comparing the particular attempted user credentials with all other attempted user credentials for that particular account since the last successful authentication for that particular account, and may proceed to step 614. However, authentication server 116 may determine that the particular attempted user credentials may not be distinct when comparing the particular attempted user credentials with all other attempted user credentials for that particular account over the lifetime of that particular account. In that instance, authentication server 116 may not increment lifetime counter 136 and proceed to step 616.

At step 614, authentication server 116 may increment the counter 136 keeping track of distinct user credential attempts.

At step 616, authentication server 116 may determine if any counter 136 has exceeded a threshold value. In certain embodiments, authentication server 116 may have threshold values for counters 136 associated with user accounts 124. For example, a threshold value may be a number predefined by an administrator of provisioned computing resources environment 104 to determine whether the attempted user credentials that are being received are from a bona fide user that may be entering the user credentials incorrectly or by a malicious entity trying to guess the password to gain unauthorized access to provisioned computing resources envi-

ronment 104. When a certain counter 136 associated with a particular user account 124 reaches or exceeds the threshold value, then the example method may proceed to step 618. Otherwise, the example method may return to step 600.

At step 618, a remediation action based on a security policy may be triggered. An example of a security policy may be to lock user accounts 124 that have at least one counter 136 that has exceeded the threshold value until further action is taken. Examples of further action is changing user credentials associated with user account 124, entering information in addition to user credentials, or replying to security questions. Another example of a security policy is contacting the user associated with a particular user account 124 regarding numerous incorrect attempted user credentials. The user may be contacted via phone, email, text message, or any other method of communication. A further example of a security policy is presenting the user with a CAPTCHA test that, for example, requires the user to input a series of text characters displayed in an image in addition to user credentials. Requiring the user to correctly answer the CAPTCHA test may serve the purpose of determining whether the user is really a malicious automated entity, or a malicious human-aided entity, incapable of correctly answering a CAPTCHA test. The security policy may be any one of the previous examples, a combination of the previous examples, or any other security policy suitable for particular needs of provisioned computing resources environment 104. Example method may then skip to the end of the example method.

At step 620, if authentication server 116 determines that the attempted user credentials match the user credentials associated with the particular user account 124, then authentication server 116 may reset instance counter 136 associated with the particular user account 124. For example, authentication server 116 may reset instance counter 136 to 0. Example method may proceed to step 622 where authentication server 116 may check if any other security policy may apply. For example, a user that may have entered correct user credentials may have a security policy associated with the particular user account 124 that requires a user credential change. If a security policy applies, then the example method may proceed to step 624. At step 624, the security policy may be initiated. Otherwise, the example method may proceed to step 626 where the user is authenticated to use services 118 of provisioned computing resources environment 104.

FIG. 7 illustrates an example computer system 700 that may be used for one or more portions of the example system 100 of FIG. 1, according to certain embodiments of a present disclosure. Although the present disclosure describes and illustrates a particular computer system 700 having particular components in a particular configuration, the present disclosure contemplates any suitable computer system having any suitable components in any suitable configuration. Moreover, computer system 700 may have taken any suitable physical form, such as for example one or more integrated circuit (ICs), one or more printed circuit boards (PCBs), one or more handheld or other devices (such as mobile telephones or PDAs), one or more personal computers, one or more super computers, one or more servers, and one or more distributed computing elements. Portions or all of computer 106, authentication server 116, and services 118 may be implemented using all of the components, or any appropriate combination of the components, of computer system 700 described below.

Computer system 700 may have one or more input devices 702 (which may include a keypad, keyboard, mouse,

stylus, or other input devices), one or more output devices **704** (which may include one or more displays, one or more speakers, one or more printers, or other output devices), one or more storage devices **706**, and one or more storage media **708**. An input device **702** may be external or internal to computer system **700**. An output device **704** may be external or internal to computer system **700**. A storage device **706** may be external or internal to computer system **700**. A storage medium **708** may be external or internal to computer system **700**.

System bus **710** couples subsystems of computer system **700** to each other. Herein, reference to a bus encompasses one or more digital signal lines serving a common function. The present disclosure contemplates any suitable system bus **710** including any suitable bus structures (such as one or more memory buses, one or more peripheral buses, one or more a local buses, or a combination of the foregoing) having any suitable bus architectures. Example bus architectures include, but are not limited to, Industry Standard Architecture (ISA) bus, Enhanced ISA (EISA) bus, Micro Channel Architecture (MCA) bus, Video Electronics Standards Association local (VLB) bus, Peripheral Component Interconnect (PCI) bus, PCI-Express bus (PCI-X), and Accelerated Graphics Port (AGP) bus.

Computer system **700** includes one or more processors **712** (or central processing units (CPUs)). A processor **712** may contain a cache **714** for temporary local storage of instructions, data, or computer addresses. Processors **712** are coupled to one or more storage devices, including memory **716**. Memory **716** may include RAM **718** and ROM **720**. Data and instructions may transfer bi-directionally between processors **712** and RAM **718**. Data and instructions may transfer uni-directionally to processors **712** from ROM **720**. RAM **718** and ROM **720** may include any suitable computer-readable storage media.

Computer system **700** includes fixed storage **722** coupled bi-directionally to processors **712**. Fixed storage **722** may be coupled to processors **712** via storage control unit **707**. Fixed storage **722** may provide additional data storage capacity and may include any suitable computer-readable storage media. Fixed storage **722** may store an operating system (OS) **724**, one or more executables (EXECs) **726**, one or more applications or programs **728**, data **730**, and the like. Fixed storage **722** is typically a secondary storage medium (such as a hard disk) that is slower than primary storage. In appropriate cases, the information stored by fixed storage **722** may be incorporated as virtual memory into memory **716**. In certain embodiments, fixed storage **722** may include network resources, such as one or more storage area networks (SAN) or network-attached storage (NAS).

Processors **712** may be coupled to a variety of interfaces, such as, for example, graphics control **732**, video interface **734**, input interface **736**, output interface **737**, and storage interface **738**, which in turn may be respectively coupled to appropriate devices. Example input or output devices include, but are not limited to, video displays, track balls, mice, keyboards, microphones, touch-sensitive displays, transducer card readers, magnetic or paper tape readers, tablets, styli, voice or handwriting recognizers, biometrics readers, or computer systems. Network interface **740** may couple processors **712** to another computer system or to network **742**. Network interface **740** may include wired, wireless, or any combination of wired and wireless components. Such components may include wired network cards, wireless network cards, radios, antennas, cables, or any other appropriate components. With network interface **740**, processors **712** may receive or send information from or to

network **742** in the course of performing steps of certain embodiments. Certain embodiments may execute solely on processors **712**. Certain embodiments may execute on processors **712** and on one or more remote processors operating together.

In a network environment, where computer system **700** is connected to network **742**, computer system **700** may communicate with other devices connected to network **742**. Computer system **700** may communicate with network **742** via network interface **740**. For example, computer system **700** may receive information (such as a request or a response from another device) from network **742** in the form of one or more incoming packets at network interface **740** and memory **716** may store the incoming packets for subsequent processing. Computer system **700** may send information (such as a request or a response to another device) to network **742** in the form of one or more outgoing packets from network interface **740**, which memory **716** may store prior to being sent. Processors **712** may access an incoming or outgoing packet in memory **716** to process it, according to particular needs.

Certain embodiments involve one or more computer-storage products that include one or more tangible, computer-readable storage media that embody software for performing one or more steps of one or more processes described or illustrated herein. In certain embodiments, one or more portions of the media, the software, or both may be designed and manufactured specifically to perform one or more steps of one or more processes described or illustrated herein. Additionally or alternatively, one or more portions of the media, the software, or both may be generally available without design or manufacture specific to processes described or illustrated herein. Example computer-readable storage media include, but are not limited to, CDs (such as CD-ROMs), FPGAs, floppy disks, optical disks, hard disks, holographic storage devices, ICs (such as ASICs), magnetic tape, caches, PLDs, RAM devices, ROM devices, semiconductor memory devices, and other suitable computer-readable storage media. In certain embodiments, software may be machine code which a compiler may generate or one or more files containing higher-level code which a computer may execute using an interpreter.

As an example and not by way of limitation, memory **716** may include one or more tangible, computer-readable storage media embodying software and computer system **700** may provide particular functionality described or illustrated herein as a result of processors **712** executing the software. Memory **716** may store and processors **712** may execute the software. Memory **716** may read the software from the computer-readable storage media in mass storage device **706** embodying the software or from one or more other sources via network interface **740**. When executing the software, processors **712** may perform one or more steps of one or more processes described or illustrated herein, which may include defining one or more data structures for storage in memory **716** and modifying one or more of the data structures as directed by one or more portions the software, according to particular needs.

In certain embodiments, the described processing and memory elements (such as processors **712** and memory **716**) may be distributed across multiple devices such that the operations performed utilizing these elements may also be distributed across multiple devices. For example, software operated utilizing these elements may be run across multiple computers that contain these processing and memory elements. Other variations aside from the stated example are contemplated involving the use of distributed computing.



In addition or as an alternative, computer system 700 may provide particular functionality described or illustrated herein as a result of logic hardwired or otherwise embodied in a circuit, which may operate in place of or together with software to perform one or more steps of one or more processes described or illustrated herein. The present disclosure encompasses any suitable combination of hardware and software, according to particular needs.

Although the present disclosure describes or illustrates particular operations as occurring in a particular order, the present disclosure contemplates any suitable operations occurring in any suitable order. Moreover, the present disclosure contemplates any suitable operations being repeated one or more times in any suitable order. Although the present disclosure describes or illustrates particular operations as occurring in sequence, the present disclosure contemplates any suitable operations occurring at substantially the same time, where appropriate. Any suitable operation or sequence of operations described or illustrated herein may be interrupted, suspended, or otherwise controlled by another process, such as an operating system or kernel, where appropriate. The acts can operate in an operating system environment or as stand-alone routines occupying all or a substantial part of the system processing.

Although the present disclosure has been described with several embodiments, diverse changes, substitutions, variations, alterations, and modifications may be suggested to one skilled in the art, and it is intended that the disclosure encompass all such changes, substitutions, variations, alterations, and modifications as fall within the spirit and scope of the appended claims.

What is claimed is:

1. A computer-implemented method, comprising:
  - obtaining, at a server, a first authentication attempt comprising user credentials that include a first claim of identity and a first attempt to prove password possession;
  - in response to obtaining the first authentication attempt:
    - updating, at the server, at least one counter of a plurality of counters associated with the password as a result of a first determination that the first authentication attempt fails authentication based at least in part on the first attempt to prove password possession matching a password in a set of passwords, and the first claim of identity being a mismatch to an identity associated with the password;
    - as a result of determining that the user credentials are distinct based at least in part on a use of a filter associated with the at least one counter, storing, at the server, a hash representation of the user credentials;
  - in response to receiving a second authentication attempt that includes a second claim of identity and a second attempt to prove password possession:
    - maintaining, at the server, a current state of the at least one counter as a result of a second determination that the second authentication attempt fails authentication based at least in part on the second attempt to prove password possession matching the password, and the second claim of identity matching the first claim of identity and being a mismatch to the identity associated with the password; and
    - in response to determining that the counter has reached a predetermined value relative to a threshold, causing a remediation action to be performed according to a security policy.

2. The computer-implemented method of claim 1, further comprising:
  - in response to determining that the first claim of identity is a match to a second identity different than the identity and determining that the first attempt to prove password possession is a mismatch to a second password associated with the second identity, incrementing another counter of the plurality of counters, the other counter associated with the second identity.
3. The computer-implemented method of claim 1, further comprising:
  - determining that the second claim of identity is a match to the first claim of identity includes determining that at least a portion of the second claim of identity is matched by the filter.
4. The computer-implemented method of claim 1, further comprising:
  - in response to receiving a third authentication attempt that includes a third claim of identity and a third attempt to prove password possession:
    - as a result of determining that the third attempt to prove password possession matches the password and that the third claim of identity matches the identity associated with the password, authenticating the third authentication attempt.
5. The computer-implemented method of claim 4, wherein:
  - processing the first authentication attempt includes:
    - incrementing an instance counter associated with the password; and
    - incrementing a lifetime counter associated with the password; and
  - authenticating the third authentication attempt includes:
    - resetting the instance counter associated with the password; and
    - not resetting the lifetime counter associated with the password.
6. The computer-implemented method of claim 1, wherein the remediation action remains in effect until a security action is successfully performed.
7. The computer-implemented method of claim 1, wherein the remediation action includes at least one of:
  - locking an account associated with the password,
  - initiating a challenge-response test, or
  - prompting a password change for the identity associated with the password.
8. A system, comprising:
  - one or more processors; and
  - memory including instructions that, as a result of execution by the one or more processors, cause the system to:
    - obtain a set of user credentials associated with a user account and at least one counter of a plurality of counters;
    - store the set of user credentials and the at least one counter of the plurality of counters;
    - as a result of determining that a first attempted set of credentials is distinct from the set of user credentials based at least in part on a use of a filter associated with the counter:
      - update the at least one counter; and
      - store a hash representation of the first attempted set of credentials;
    - as a result of determining that a second attempted set of credentials is distinct from the set of user credentials based at least in part on the second attempted set of credentials matching the first attempted set of cre-

dentials, maintain a current state of the at least one counter of the plurality of counters;  
 as a result of determining that a third attempted set of credentials is distinct from the set of user credentials based at least in part on the third attempted set of credentials being distinct from the second attempted set of credentials and being distinct from the first attempted set of credentials, update the at least one counter of the plurality of counters; and  
 in response to a determination that the at least one counter of the plurality of counters has reached a predetermined value relative to a security policy threshold, initiate a remediation response in accordance with an applicable security policy.

**9.** The system of claim **8**, wherein the instructions further include instructions that cause the system to, as a result of determining that an attempted set of user credentials matches the set of user credentials, reset the at least one counter of the plurality of counters.

**10.** The system of claim **8**, wherein the remediation response includes at least one of:  
 locking the user account,  
 initiating a challenge-response test, or  
 contacting a user associated with the user account to notify of incorrect attempted user credentials.

**11.** The system of claim **8**, wherein:  
 the instructions that cause the system to, as a result of the determination that the first attempted set of credentials is distinct from the set of user credentials, further include instructions that cause the system to increment a lifetime counter associated with the set of user credentials; and  
 the instructions further include instructions that cause the system to, as a result of a determination that an attempted set of user credentials matches the set of user credentials, perform an authentication process that includes not incrementing the lifetime counter.

**12.** The system of claim **8**, wherein:  
 the at least one counter of the plurality of counters is an instance counter associated with a specific time period; and  
 the instructions further cause the system to, as a result of an expiration of the specific time period, reset the instance counter.

**13.** A non-transitory computer-readable storage medium comprising executable instructions that, as a result of being executed by one or more processors of a computer system, cause the computer system to at least:  
 store a set of distinct identities and a set of passwords, individual passwords of the set of passwords corresponding to identities in the set of distinct identities;  
 as a result of determining that a first attempt to prove password possession is a match to a password in the set of passwords, but that a first identity claim is a mismatch to an identity of the set of distinct identities that corresponds to the password, update at least one counter of the plurality of counters associated with the password;  
 as a result of determining that the first identity claim of the first attempt is distinct based at least in part on a use of a filter associated with the at least one counter, store a hash representation of the password and the first identity claim of the first attempt;  
 as a result of determining that a second attempt to prove password possession is a match to the password and that a second identity claim, received in association with the second attempt to prove password possession,

is a mismatch to the first identity claim based at least in part on information indicated in the stored hash representation, update the at least one counter of the plurality of counters associated with the password; and  
 in response to determining that the at least one counter of the plurality of counters has reached a predetermined value relative to a threshold, cause a remediation action to be performed.

**14.** The non-transitory computer-readable storage medium of claim **13**, wherein the executable instructions further include executable instructions that cause the computer system to:  
 receive a third identity claim and a third attempt to prove password possession; and as a result of determining that the third attempt to prove password possession is a match to the password, increment the at least one counter of the plurality of counters associated with the password as a result of the third identity claim being a mismatch to the second identity claim and is a mismatch to the first identity claim.

**15.** The non-transitory computer-readable storage medium of claim **13**, wherein:  
 the at least one counter of the plurality of counters is an instance counter associated with a specific time period; and  
 the executable instructions further cause the computer system to, as a result of an expiration of the specific time period, reset the instance counter.

**16.** The non-transitory computer-readable storage medium of claim **13**, wherein the executable instructions further include executable instructions that cause the computer system to, as a result of determining that the first identity claim matches a second user identity different than the identity, but that the first attempt to prove password possession is a mismatch to a password that corresponds to the second user identity, increment a second counter associated with the second user identity.

**17.** The non-transitory computer-readable storage medium of claim **13**, wherein the remediation action performed is based at least in part on a security policy.

**18.** The non-transitory computer-readable storage medium of claim **13**, wherein:  
 the remediation response includes one or more of:  
 locking an account associated with the identity that corresponds to the password,  
 sending a message to a destination associated with the account to notify a number of unsuccessful identity claim attempts using the password, or  
 presenting a challenge-response test to a requestor attempting to claim the identity; and  
 the remediation response remains in effect until a security action is successfully performed.

**19.** The non-transitory computer-readable storage medium of claim **18**, wherein successful performance of the security action includes one or more of:  
 changing the password corresponding to the identity,  
 receiving a successful challenge-response, or  
 receiving additional information in an identity claim that provides proof of the identity that corresponds to the password.

**20.** The non-transitory computer-readable storage medium of claim **18**, wherein sending a message to a destination associated with the account include one or more of:  
 sending an email message to an email address associated with the account,

sending a text message to a mobile device associated with  
the account, or  
calling a voice communication device associated with the  
account.

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